TWO SECTIONS—SECTION 1

# Engineering News

Volume 76, No. 26
Issued Every Thursday
Hill Publishing Company

NEW YORK, DECEMBER 28, 1916

Price, 15 Cents
Contents, First Page
Advertising Index, Last Page

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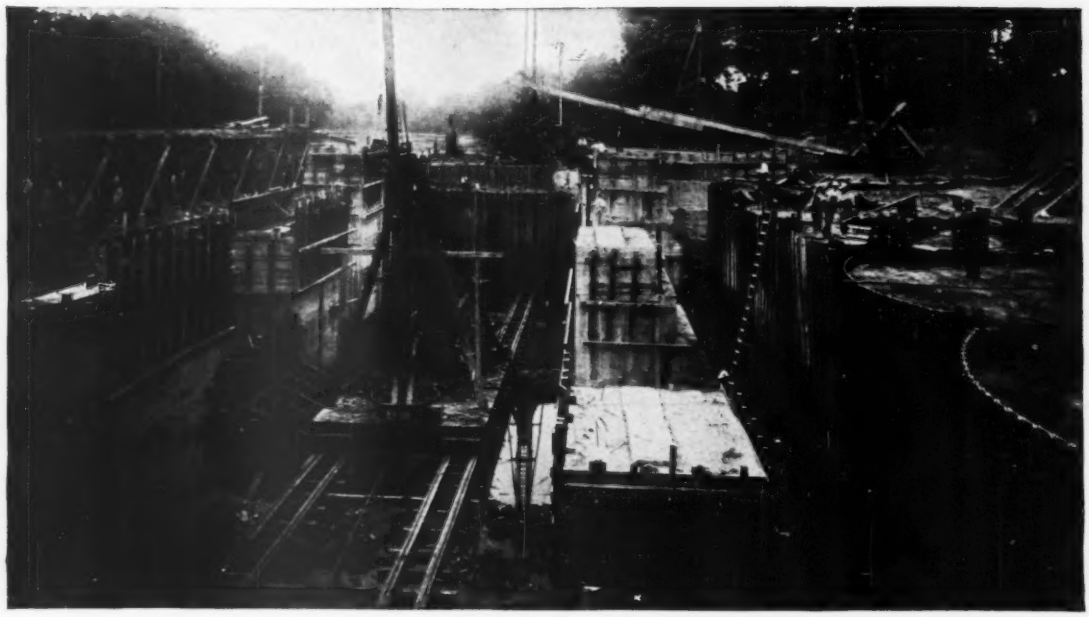

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272

Engineering News

VOLUME 76 DECEMBER 28, 1916 NUMBER 26

# Flushing Streets from Trolley Cars at Worcester, Mass.

Trolley-car street flushers have been in use in the cities of Worcester and Springfield, Mass., for over a year. Worcester was the first city in the country to introduce street-car sprinklers, and in 1915 it was the first to introduce the new street-car flushers. A. T. Rhodés, Street Commissioner of Worcester, from whom the following data were obtained, states that these machines are operated throughout the entire season with great satisfaction —so much so that during the present year (1916), the older methods of street cleaning have been abandoned on all paved streets where there are electric-railway tracks.

FIG. 1. STREET-FLUSHING TROLLEY CAR AS USED AT WORCESTER, MASS.

The flushing machine used is a trolley car, containing a tank with a capacity of 2,900 gal. The tanks are filled from subsurface hydrants placed between the rails or tracks of the trolley system, and accessible by removing ordinary sewer manhole covers. The temporary connection is made by flexible leather pipes.

The pressure for flushing is obtained by a centrifugal pump having a maximum capacity of from 500 to 600 gal. per min., a speed of 2,600 r.p.m., giving a normal working pressure of 80 lb. per sq.in. The pump is driven by a 45-hp. electric motor. The pump discharge is equipped with a bypass, enabling the operator to cut down the nozzle pressure to as low as 30 lb. per sq.in. The operation of the car and flushing apparatus requires a crew of three men.

On the wide streets there are five nozzles pointing in the direction the car is going, three on the car and two on the swinging arms (see Fig. 1). One of the three nozzles on the car, on a double-track street, catches the refuse lying on the paving between the two tracks and throws it to the opposite track, then the return trip in the opposite direction catches the material and flushes it to the gutter.

Sprinkling within an hour ahead of the flushing has been found to be essential for the best results. For this purpose the older sprinkler type cars are economically used. The sprinkling softens up any deposits which are stuck down on the pavement and makes it easy to remove them with the flusher. The new flusher cars have the original sprinkling attachments, both on the car and on the swinging arm, so that the same car can

be used for both sprinkling and completing the work with the flushing nozzles, if so desired.

With preliminary sprinkling a car flusher will cover about 10.5 mi. of street per night. The average eight hours' work for a car doing both sprinkling and flushing is about 9 mi. of street varying from 25 to 75 ft. between curbs. During eight hours' use the car flusher distributes approximately 95,700 gal. of water. One tank of water is sufficient to sprinkle a street 38 to 45 ft. wide between curbs a distance of about one mile. The same tank of water will properly flush between one-quarter and one-third of a mile.

Previous to the adoption by the city of the method of flushing at night, the streets were sprinkled by trolley cars during the day. Under the day sprinkling system the water simply laid the dust, and the other refuse which had accumulated upon the street surface remained, forming a greasy, slippery scum on the surface, extremely dangerous to vehicular traffic. Night flushing has made it possible to discontinue sprinkling during the day.

When the day sprinkling was in operation three car sprinklers, making several trips over each street every day, covered the same area now covered by two flushers, making one round trip nightly, for sprinkling and flushing combined. The flushers work eight hours, and the sprinklers under the old method worked 14 hr. per day. The amount of water used under the flushing system is about 60% of that used under the old style sprinkling, while the present combined sprinkling and flushing requires about 85% of the former amount.

Previous to the installation of this system two machine broom squads were worked at night, covering these paved streets from two to three times per week. This work cost $14,000 yearly and was not very satisfactory. Moreover, it was difficult to keep track of the labor during the night hours. This has been discontinued entirely; the only cleaning necessary is taken care of by pushcart men, the first thing in the morning. They clean up the gutters, and owing to the fact that the streets are absolutely clean when they reach them, their labors have not been increased nor is there any additional expense incurred.

The cost of catchbasin cleaning has been just about doubled on streets which are flushed. The average cost per catchbasin per year for cleaning was $1.95, and on streets flushed this has been increased to $3.90.

The street-car flushers and sprinklers are operated under contract with the American Car Sprinkler Co., of Worcester, which in turn makes the contract with the street railway company for use of tracks and for power.

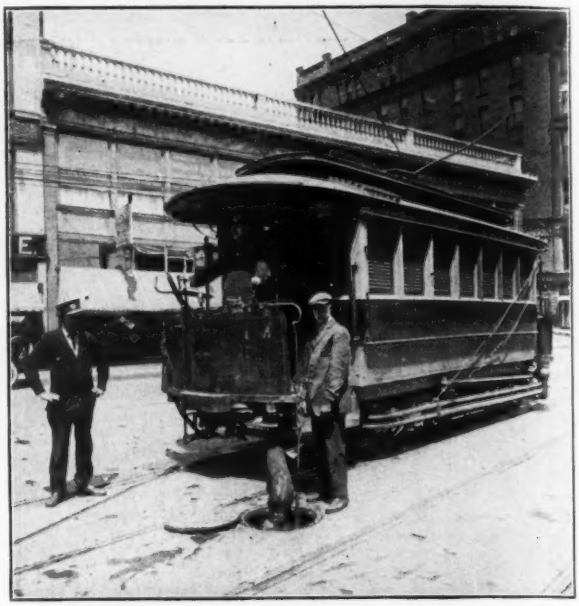


FIG. 3. FILLING CAR FROM SUBSURFACE HYDRANT

Each car is equipped with "Servis" recorders, as a check on the mileage covered. The accompanying tables give the contract prices for flushing and for sprinkling. The assesments against abutting property for street cleaning vary by ½c. per lin.ft. for each 5 ft. in width of street from 3½c. for a 25-ft. street to 10c. for an 80-ft. street. The American Car Sprinkler Co. has similar contracts with Malden, New Bedford, Springfield and Somerville, Mass., Manchester, N. H., and Syracuse, N. Y.

Similar methods have been employed in Worcester by using motor-truck flushers and sprinklers. The two

FIG. 2. FLUSHING CAR USING SPRINKLING APPARATUS

trucks now in use there average together about 5 mi. of streets per night, but in addition the trucks do some sprinkling and flushing to help out the trolley work. There are not enough paved streets without trolley tracks to make their independent operation economical.

TABLE 1. CONTRACT PRICES OF WORCESTER STREET SPRINKLING AND FLUSHING

| Street Sprinkling | | Street Flushing | |
|---|---|---|---|
| Width of Street, Ft. | Cost per Mile | Width of Street, Ft. | Cost per Mile |
| 25 | $396.00 | 25 | $448.80 |
| 30 | 464.64 | 30 | 552.72 |
| 35 | 533.28 | 35 | 596.64 |
| 40 | 564.96 | 40 | 633.60 |
| 45 | 596.64 | 45 | 670.56 |
| 50 | 665.28 | 50 | 749.76 |
| 55 | 733.92 | 55 | 823.68 |
| 60 | 929.28 | 60 | 1,045.44 |
| 65 | 997.92 | 65 | 1,119.36 |
| 70 | 1,129.92 | 70 | 1,272.48 |
| 75 | 1,198.56 | 75 | 1,346.40 |
| 80 | 1,261.92 | 80 | 1,420.32 |

TABLE 2. ASSESSMENT PER FRONT FOOT ON ABUTTING PROPERTY

| Width of Street, Ft. | Per Lin.Ft. Cents | Width of Street, Ft. | Per Lin.Ft., Cents |
|---|---|---|---|
| 25 | 3½ | 60 | 7½ |
| 30 | 4 | 65 | 8 |
| 35 | 4½ | 70 | 9 |
| 40 | 4½ | 75 | 9½ |
| 45 | 5 | 80 | 10 |
| 50 | 5½ | 100 | 11½ |
| 55 | 6 | | |

## Bottom Driven Concrete Piles on Government Job

By C. S. Howell*

Reinforced-concrete piles of the Giant type, that is piles which are driven by a temporary follower against projections on the pile point (see *Engineering News*, Mar. 2, 1916), are being successfully used on a new Federal building at Wilmington, N. C., under conditions which it was considered precluded the use of piles entirely. A typical pile section and location is shown in the accompanying drawing.

The site of this work was formerly covered with buildings which were razed to make way for a new Custom House, Appraiser's Stores and Court House. The old foundations were left below the surface of ground practically intact. Under these, the earth is generally a mixture of fine blue sand mixed with clay, and in places heavy beds of a substance resembling asphalt have been encountered. The consistency of the earth penetrated is such that excavation is extremely difficult, due to adhesion to the excavating implements, and the earth has refused to yield to enormous water pressure applied through jets.

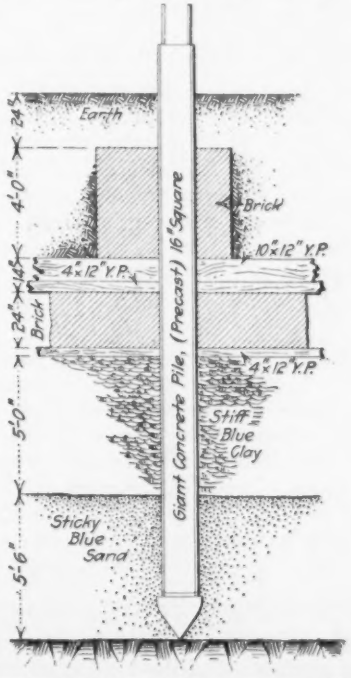
The piles are driven in an average time of eight minutes, actual driving, to refusal upon the underlying coral rock.

The work involves 710 piles, with an average depth of 25 ft. They are driven with a No. 0 Vulcan steam hammer, weighing 17,500 lb. and delivering 1,800,000 ft.-lb. per min. The piles are 16-in. square and contain four ¾-in. square deformed bars which are looped or hooked through the cast-iron point and tied at intervals to maintain uniform spacing.

### Why Not Design Piles for Loads?

In connection with this work it has occurred to the writer to inquire why concrete piles should not be proportioned to the load they must carry. With wooden piles natural restrictions made it quite general to load without regard to the size of the pile, probably because there did not exist any great variation in size with regard to ratio of end diameters to length. The introduction of concrete piles did not involve this fixed condition but opened the way to proportioning size to imposed loading. Yet it is notable that little use of this important fact is now resorted to. Concrete piles are placed without regard to the individual capacity of the pile selected. By means of the method described by the writer in *Engineering News*, Apr. 27, 1916, it is possible without difficulty to apply the Wellington formula so that the load capacity is obtained, accordingly leaving no good reason for not selecting any particular pile upon the basis of its suitability and its cost per ton of load carried rather than by the haphazard manner most generally followed.

The pile shown in the sketch herewith is good under the New York building regulations for about 65 tons




SECTION OF GROUND THROUGH WHICH WILMINGTON, N. C., PILE WAS DRIVEN

safe load, which is in full accord with the usual conservative practice regarding stresses allowed in superstructures subjected to vibration and other sources of danger not involved to the same degree in substructures. As a quite general thing in foundation work it will be found that plans are prepared for a fixed number of piles, and the type of pile as well as its load capacity are given little consideration in competition upon cost, whereas a consideration of the simplicity of work in adopting piles to foundation layouts would involve more exact competition both upon cost and merit.

Building regulations are striving to regulate rule-of-thumb methods, as in New York City where 500 lb. per sq.in. of cross-section is allowed upon precast piles and 350 lb. upon cast-in-place piles, and also where average cross-section applies in case of tapered piles. Aside from such regulations, the custom largely prevails of using so many piles upon customary centers more according to footing areas than to the capacity of the piles.

*Civil Engineer, 550 W. 174th St., New York City.

# Rainfall Data Interpreted by Laws of Probability

By Thorndike Saville*

*SYNOPSIS—Presents enough theory, with examples, to make the probability method available to those not proficient in the use of least squares. Indicates practical applications not in general use.*

The interpretation of physical observations may be greatly enhanced by the application of the laws of probability. This method is one not in general use by engineers, due possibly to the limited extent of adequate knowledge regarding it. The writer presents herewith an outline of the method and computations involved in its application to the rainfall data of Hartford, Conn.

### Mean of a Series of Observations

The method finds its basis in the general laws of probability which may be found in any textbook on least squares. In any series of recorded observations having equal weight and upon the same quantity, it is mathematically true and has been generally assumed that the most probable value is the average or mean of the observations. Where $M_1$, $M_2$, $M_3$, . . . $M_n$ represent $n$ single observations of equal weight on a single quantity (such as yearly records of rainfall) the most probable value of that quantity is $\frac{M_1 + M_2 + M_3 + \ldots\ldots M_n}{n}$.

Thus in Table 1, column 1, the most probable value of the annual rainfall at Hartford is about 44 in. This, or any, most probable value is more or less probable, according to the number and frequency of the observations. The probable error of the mean is explained in the following section. The lower the probable error, in general the more accurate the series of observations, and the more probable the mean of the series.

### Variations and Probable Error

The amount by which any observation in a series differs from the mean is called the residual or "variation," and is expressed by $v$. Thus if $M_1$, $M_2$, $M_3$, etc., represent any series of observations and $P$ represents the mean of the series, then $P - M_1 = v_1$, $P - M_2 = v_2$, $P - M_3 = v_3$, etc. The variations of the annual rainfall at Hartford from the 47-year mean are given in Table 1, column 2.

The calculation of the variations may be considerably shortened by taking the mean to the nearest even inch, and subtracting each individual observation. The error introduced is not appreciable in rainfall computations. (See King's "Elements of Statistical Methods," page 149).

By the laws of probability, the mathematical deductions of which are here omitted, "in measurements of equal precision the most probable values of observed quantities are those which render the sum of the squares of the residual errors (variations) a minimum."[1] Hence the term "least squares." The squares of the variations for the Hartford data are tabulated in Table 1, column 3.

The most probable value of a series of observations of equal weight upon a single quantity is then the arithmetic mean. Thus if

$Z$ = Most probable value of a term in a series of observations;
$n$ = Number of observations;
$M$ = Any observation;
$v$ = Variation of a single observation from the mean;
$r$ = Probable error of a single observation;
$R$ = Probable error of the mean;
$\Sigma$ = Sum of.

Then, omitting mathematical proof,

$$Z = \frac{\Sigma M}{n}, \quad r = 0.6745\sqrt{\frac{\Sigma v^2}{n-1}},$$

$$R = \frac{r}{\sqrt{n}} = 0.6745\sqrt{\frac{\Sigma v^2}{n(n-1)}}$$

The quantity $\sqrt{\frac{\Sigma v^2}{n-1}}$ is called the "standard variation."

TABLE 1. STUDY OF RAINFALL DATA, HARTFORD, CONN.

| Yearly Rainfall in Inches in Order of Magnitude | Variations from the Mean | Variations Squared | Percentage of Total for Plotting |
|---|---|---|---|
| 33.64 | 10.34 | 106.92 | 0.0106 |
| 34.11 | 9.89 | 97.81 | 0.032 |
| 34.78 | 9.22 | 85.01 | 0.053 |
| 35.74 | 8.46 | 71.57 | 0.074 |
| 36.02 | 7.98 | 63.68 | 0.096 |
| 36.88 | 7.12 | 50.69 | 0.117 |
| 36.91 | 7.09 | 50.27 | 0.134 |
| 37.04 | 6.96 | 48.44 | 0.160 |
| 37.68 | 6.32 | 39.94 | 0.180 |
| 38.25 | 5.75 | 33.06 | 0.201 |
| 38.95 | 5.05 | 25.50 | 0.224 |
| 39.16 | 4.84 | 23.43 | 0.245 |
| 39.45 | 4.55 | 20.70 | 0.266 |
| 39.73 | 4.27 | 18.23 | 0.288 |
| 40.17 | 3.83 | 14.67 | 0.309 |
| 40.75 | 3.25 | 10.56 | 0.330 |
| 41.09 | 2.91 | 8.47 | 0.351 |
| 41.53 | 2.47 | 6.10 | 0.372 |
| 41.56 | 2.44 | 5.95 | 0.394 |
| 42.07 | 1.93 | 3.72 | 0.415 |
| 42.07 | 1.93 | 3.72 | 0.436 |
| 42.20 | 1.80 | 3.24 | 0.457 |
| 42.42 | 1.58 | 2.50 | 0.478 |
| 43.60 | 0.40 | 0.16 | 0.499 |
| 43.66 | 0.34 | 0.12 | 0.522 |
| 45.35 | 1.35 | 1.82 | 0.543 |
| 45.37 | 1.37 | 1.88 | 0.564 |
| 45.54 | 1.54 | 2.37 | 0.585 |
| 45.62 | 1.62 | 2.62 | 0.606 |
| 45.83 | 1.83 | 3.35 | 0.627 |
| 46.32 | 2.32 | 5.58 | 0.650 |
| 46.81 | 2.81 | 7.90 | 0.671 |
| 47.13 | 3.13 | 9.80 | 0.692 |
| 47.29 | 3.29 | 10.82 | 0.713 |
| 48.47 | 4.47 | 19.98 | 0.735 |
| 48.71 | 4.71 | 22.18 | 0.756 |
| 49.22 | 5.22 | 27.25 | 0.777 |
| 49.26 | 5.26 | 27.67 | 0.798 |
| 50.25 | 6.25 | 39.06 | 0.819 |
| 50.29 | 6.29 | 39.56 | 0.840 |
| 51.66 | 7.66 | 58.68 | 0.861 |
| 52.00 | 8.00 | 64.00 | 0.882 |
| 52.69 | 8.69 | 75.52 | 0.903 |
| 53.59 | 9.59 | 91.97 | 0.924 |
| 55.12 | 11.12 | 123.65 | 0.945 |
| 55.81 | 11.81 | 139.48 | 0.967 |
| 56.36 | 12.36 | 152.77 | 0.990 |
| $\Sigma M = 2,067.95$ | | $\Sigma v^2 = 1,722.17$ | |
| $\frac{\Sigma M}{n} = \frac{2,067.95}{47}$ | | $R = 0.6745\sqrt{\frac{\Sigma v^2}{n(n-1}}$ | $\sqrt{\frac{\Sigma v^2}{n-1}}$ |
| $= 44.00$ | | $= 0.6020$ | $= 6.119$ |
| The Mean | | Probabl Error of th Mean | Standard Variation |

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[1] "Textbook on the Method of Least Squares," by Mansfield Merriman.

tion," and the ratio of the standard variation to the mean, that is, $\frac{\sqrt[n]{\frac{\Sigma v^2}{n-1}}}{\Sigma M}$, is called the "coefficient of variation." The first term is simply the expression for probable error of a single observation with the constant 0.6745 omitted. The coefficient of variation indicates the frequency of departure of single observations from the mean, and serves as a means of comparing similar data from different localities. The application of this coefficient to the interpretation of rainfall data has been presented by Allen Hazen in *Engineering News*, Jan. 6, 1916. The following remarks are taken from his article on "Variation in Annual Rainfall":

> **The coefficient of variation is lowest on the Atlantic coast. That means that one can count on getting more nearly the normal rainfall each year; and on the Atlantic coast the coefficient does not range through wide limits. . . . As one goes west, the coefficient in annual rainfall increases; that is to say, the chance of a very dry or a very wet (relatively) year is increased. . . . At New York the coefficient of variation is 0.15; at San Francisco it is 0.30. This means that on the average the relative variations in annual rainfall at San Francisco are twice as great as at New York.**

The coefficient of variation for Hartford, as computed[2] from the data in Table 1, is thus from the formula above $\frac{\sqrt[47]{\frac{1,722.17}{46}}}{2,067.95} = 0.139$, which does not vary greatly from that at New York.

When used in the interpretation of rainfall data it is evident that the quantity called here the "probable error" is not an expression of error, but an indication of the annual variations from the mean, although observational errors are also included in the adjustment. It represents, let us say, the error of nature in not providing a constant annual rainfall. This annual deviation and its frequency is best expressed by the coefficient of variation, although, as can be seen from the formula, this latter is dependent upon the probable error, so called. The relation between these two quantities is indicated in the table below, a low probable error producing a low coefficient of variation.

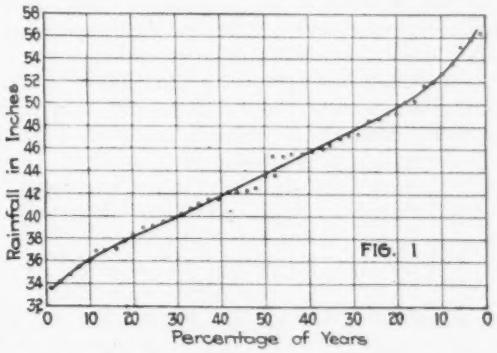
From these figures it is evident that individual observations of rainfall extending over long periods of time do not necessarily tend to depart less from the mean than they do in certain shorter time records. Frequency of departures from the mean are dependent upon location of the place and the governing meteorological conditions, and are indicated by the magnitude of the coefficient of variation. Thus at Hartford, with a 48-year record, the annual rainfall varies less from the average than does that at Boston with a 96-year record. To be comparable, however, the observations must be of equal precision, and whether they are so in the cases cited the writer is unaware.

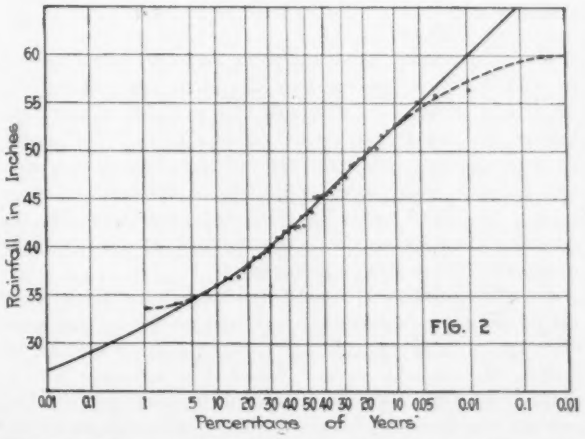
Many communities in New England will in the next decade or so have 100 years of rainfall record. When this record extends over a period greater or less than 100 years by not more than 5 years, the probable error of a single observation may be obtained nearly enough by multiplying the probable error of the mean by 10. The standard variation is then found by dividing by 0.6745. Thus for New Bedford,

TABLE 2. STUDY OF HARTFORD, BOSTON AND NEW BEDFORD RAINFALL DATA

| Place | Years of Record | Probable Error of Single Observation | Standard Variation | Probable Error of Mean | Coefficient of Variation |
|---|---|---|---|---|---|
| Hartford, Conn. .... | 48 | 4.127 | 6.119 | 0.6020 | 0.139 |
| Boston, Mass. ..... | 96 | 5.458 | 8.092 | 0.5571 | 0.178* |
| New Bedford, Mass.. | 100 | 4.468 | 6.624 | 0.4468 | 0.143* |

*"Rainfall in New England," by X. H. Goodnough, Jour. New Eng. W.-W. Assoc., Vol. XXIX, No. 3, 1915.




FREQUENCY OF RAINFALL AT HARTFORD, CONN., 1868 TO 1914, INCLUSIVE

Time = 47 Years

| Per Cent. of Time | Equivalent Years | Equals Once in | Rainfall in Inches of |
|---|---|---|---|
| 25 | 11.8 | 4 yr.* | 39 or less, or 48 or more |
| 10 | 4.7 | 10 yr. | 36 or less, or 53 or more |
| 1 | 0.47 | 100 yr. | 34 or less, or 56 or more |
| 0.1 | 0.047 | 1,000 yr. | 29 or less, or 65 or more |

*It is at once evidence that the frequency of occurrence of a rainfall of any given magnitude is obtainable at once from the curve by the simple relations that

$$\text{Frequency} = \frac{100}{\text{Per cent. of time}}$$

[2]For purposes of illustration, and to indicate how expeditiously all the quantities mentioned may be found, the following computations for the Hartford data are presented. Reference should be had to Table 1 and the formulas.

log $\Sigma v^2$ (1,722.17) = 3.23621
log n(n-1) (2,162) = 3.33486

extract square root 2) $\bar{1}.90135$

$\bar{1}.95062$

log 0.6745 = $\bar{1}.82898$

$\bar{1}.77960 = 0.6020 = R$

log $\sqrt{n}$ = 0.83605

$0.61565 = 4.127 = r$

log 0.6745 = 1.82898

$0.78667 = 6.119 =$ standard variation

log n (47) = 1.67210

log $\Sigma M$ (2,067.95 = 3.31555

$\bar{1}.14322 = 0.139 =$ coefficient of variation

log n (47) = 1.67210
log $\sqrt{n}$ = 0.83605

With care, the quantities may be computed accurately enough for most purposes by the slide rule.

$$\textit{Probable error of mean} = 0.4468$$

$$\textit{Probable error of single observation} = 0.4468 \times 10 = 4.468$$

$$\textit{Standard variation} = \frac{4.468}{0.6745} = 6.624$$

$$\textit{Coefficient of variation} = \frac{100 \times 6.624}{4{,}646.85} = 0.143$$

### Peter's Formulas for Probable Error

There are simpler formulas for obtaining probable error known as Peter's formulas. These are somewhat easier of application in that they do not necessitate computing the squares of the residuals. They are based, however, upon slightly different reasoning than the standard formulas presented above, and unless the observations follow the probability curve fairly closely the results obtained from using these formulas will differ from those obtained by use of the standard formulas. Peter's formulas are given below:

$$R = 0.8453 \frac{\Sigma v}{n\sqrt{(n-1)}} \qquad r = 0.8453 \frac{\Sigma v}{\sqrt{n(n-1)}}.$$

$$\textit{Coef. var.} = 1.25 \frac{\Sigma v}{\sqrt{n(n-1)}} \times \frac{n}{\Sigma M}$$

From these the following approximations are evident:

$$R = 0.85 \frac{\Sigma v}{n\sqrt{n}} \qquad r = 0.85 \frac{\Sigma v}{n} \qquad \textit{coef.var.} = 1.25 \frac{\Sigma v}{\Sigma M}$$

While, as stated, these formulas are considerably easier of solution than the standard formulas, they should be used only when it is known that the observational data follow the probability curve fairly closely. Ordinarily in computations involving rainfall data where comparison is likely to be made with figures obtained at other places, the chief value in these approximations lies in applying them as an independent check to computations made with the standard formulas.

Peter's formulas are presented here only from their utility as a check method, and because they have been suggested at times as offering a much simpler method of finding the probable error. Space does not permit of a discussion of the relative merits of the several formulas, but the standard formulas are those which are commonly used in scientific work.

### The Median Observation

If the series of observations be arranged in order of magnitude as in Table 1, column 1, that observation which has as many observations greater than it as there are less than it, is called the "median." In this case the median is 43.60 in. while the mean is 44 in. When there are a few very large or very small (relatively) observations entering into the calculation of the mean, the median is a better expression of the most frequent observation. When the median approaches the mean in value, as occurs in the Hartford data, it is commonly an indication that the series of observations follow closely the laws of probability. In such cases Peter's formula might be used as the shorter process. Both the median and the mean should be computed in all studies of rainfall data.

If a series of observations be arranged in order of magnitude and plotted against the frequency of their occurrence, and if they conform at all to the laws of probability, they will fall along a curve of the general form shown in Fig. 1. The Hartford rainfall data fall along a curve which closely approaches the theoretical in shape. Such a curve is defined as a "frequency curve."

In plotting such a curve as that in Fig. 1, the horizontal distance along which the abscissas will lie is divided into 100 parts. The observations, arranged in ascending order of magnitude, are plotted as ordinates, and the per cent. which each term is of the whole number of terms is plotted as abscissas. *The latter is plotted cumulatively.* Thus in Table 1, column 4, as there are 47 observations, each observation is $\frac{100}{47} = 2.128\%$ of the whole. The abscissa for the first observation is at the middle of the distance representing 2.128%, or on the 1.06% line. The next largest observation is plotted at a distance 2.128 greater than this, or on the 3.2% line; the next on the 5.4% line, etc. Hazen[3] states that the decimal position of the $m$th term in a series of $n$ terms is $P = \frac{2m-1}{2n}$. In numbering the vertical lines the numbers have for convenience been made to run from 0 to 50 and back to 0 on the bottom of the diagrams, and from 0 to 100 on the top. Thus on the 80% line it is seen that 80% of the time a rainfall of 48.8 in. or less occurred, and that 20% of the time a rainfall of 48.8 in. or more occurred. It is the extreme value, however, which is of the chief utility, as is evident from the following paragraph. For convenience in computation the percentages are calculated from 0 to 100 as in Table 1, column 4.

When observational data fall along a curve of this general type so closely as in this instance, the probability of occurrence of a rainfall of any magnitude may be found at once from the curve. The method of using the curve is evident from the data given beneath Figs. 1 and 2.

### The Straight-Line Frequency Curve

At times observational quantities when plotted do not lie smoothly along such a curve as that in Fig. 2, nor does the curve so nearly approach a straight line. In such cases, by varying the spacing of the ordinates in accordance with changes in the value of the probability integral, and by varying the spacing in the same proportion on each side of the 50% line, the ends of the curve may frequently be straightened and the data made to lie more nearly on a straight line. This line may then be produced beyond the limits of the observed data and the probability of occurrence of extraordinary phenomena predicted. The method of plotting is the same as for Fig. 1 and is illustrated in Fig. 2. The full line indicates the probable trend of the observations, while the dotted lines at each end follow more closely the plotted points. At the ends these points represent such infrequent phenomena that they are not of great value in determining the slope of the line.

At times the nature of the data is such (though rarely in rainfall studies) that the curve departs considerably from a straight line even on probability paper. Sometimes, in such instances, if the data be plotted to a

[3] "Storage To Be Provided in Impounding Reservoirs for Municipal Water-Supply," by Allen Hazen, Trans. Am. Soc. C. E., Vol. LXVII, December, 1914. This article treats in considerable detail of the application of the laws of probability to data relating to flow of streams and storage. It explains the method of using the probability curve from such data, and also the manner of constructing probability paper.

logarithmic instead of to an arithmetic scale, a better curve will be obtained.

The writer has attempted in the foregoing discussion not only to present certain applications of the laws of probability to the interpretation of rainfall data, but also by formulas and tables to make plain the utilization of such data by those who are not versed in the theories of least squares. The value of the methods indicated lies in their applicability to the interpretation of rainfall statistics and their relation to the compilation of data pertaining to freshet conditions, storage, design of spillways, sewers, culverts, etc. Thus it might be allowable to design a sewer that would likely be flooded once in 100 years, while a sewer that would be flooded once in 10 years would be undesirable.

The formulas and methods outlined herein are of wide applicability, and opportunities to utilize them will be readily apparent. In many instances in engineering work, in addition to the interpretation of rainfall data, the utilization of statistical information according to the laws of probability, and the precision discussion of results, will be found of the utmost value. A recent article in the Journal of the Franklin Institute[4] presents briefly some of the more important applications of this method, and mentions its use in statistics relating to death rates, to the number of bacteria in water and milk, to sand analysis, to filter effluents, and to precision determinations of the free and albuminoid ammonia in water. The application of the methods of least squares to a precision discussion of tests on cement and sand briquettes has been previously indicated by the author.[5]

Acknowledgment is due Prof. G. C. Whipple, of Harvard University, for certain suggestions concerning the applicability of computed data to engineering practice, and to Prof. S. L. Ruggles, of the Thayer School of Civil Engineering at Dartmouth College, for review and criticism of the manuscript.

[4] "The Element of Chance in Sanitation," Prof. G. C. Whipple, Jour. Franklin Inst., Vol. 182, Nos. 1 and 2, July and August, 1916.

[5] "Effect of Iron and Calcium on Concrete Sand," Thorndike Saville, "Engineering News," Vol. 74, No. 26, Dec. 23, 1915.

## Hydraulic Hopper Dredge with Unloading Machinery

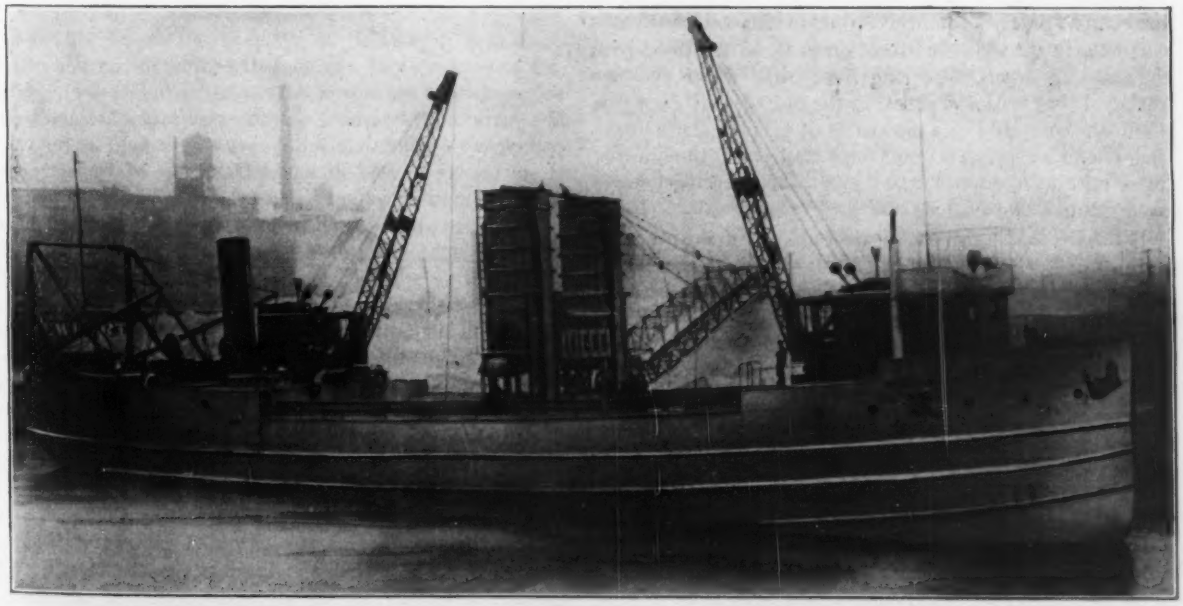
For dredging and transporting sand to be used in concrete and building construction, and also for filling, the Hydraulic Sand and Transit Co., of Chicago, has a large "sand-sucker," or suction dredge, with hopper capacity for 1,500 tons and with special equipment for putting the material ashore. This vessel—the "Hydro"—was built and equipped by the Manitowoc Ship Building Co., of Manitowoc, Wis.

This steamer is shown in the accompanying illustration. It has a steel hull 180 ft. long, 40 ft. beam and 19 ft. deep, with a draft of 10 ft. light and 14½ ft. loaded. Its displacement is 2,100 tons, and the two hoppers in the hold have combined capacity for 1,500 tons of sand. The propeller is driven by a triple-expansion engine of 650 hp.

There are two 12-in. suction pumps and pipes, and each pipe has a hinged outboard section of 12-in. rubber pipe 25 ft. long, from its connection to the fixed pipe, and having the mouth fitted with jets and teeth for loosening packed sand. These pipes are handled by booms guyed from a gallows frame at the stern of the vessel, and are swung on deck when not in use. They can dredge to a depth of about 20 ft.

If the sand is to be used for filling, it can be pumped ashore through a delivery pipe; but for storage it can be handled dry by means of grab buckets and belt conveyors. In the former case the necessary amount of water is delivered to the hoppers by means of a large force pump.

For unloading in dry condition, there are two McMyler revolving cranes, each with its own engine and boiler. These are mounted on the deck, and each handles a 1½-yd. grab bucket with a 45-ft. boom having a reach of 25 ft. for delivering the sand direct. Ordinarily, however, the grab buckets dump their contents into a hopper, beneath which runs a transverse belt conveyor. This feeds a 30-in. belt conveyor on a boom or frame 75 ft. long, which is hinged at the side of the vessel. The vessel can fill the hoppers in 1½ to 5 hr., and can discharge its load in 2½ to 4 hr. Its speed, when loaded, is about 12 m.p.h.



HYDRAULIC HOPPER DREDGE, WITH CONVEYORS AND CRANES FOR HANDLING SAND

# Side Lights on Depreciation Problems of Utilities--II*

By Harry Barker†

*SYNOPSIS—Review of schemes for computing annual depreciation of utility property and making the annual compensation approximate the annual decrement in value. Theory of steady fixed charges advanced as controlling. Compound-interest computations shown as a means of approach. How effect of increasing operating costs and decreasing capacity are taken into account. Complementary to earlier article defining depreciation and discussing the collection of compensation for it.*

The hard problem in practical depreciation studies is not to find out whether it is wear-deterioration or natural dilapidation or functional antiquation that will fix the life of various parts of plant before they have to be retired. The greater problem is, once the probable term is accepted, How shall the total loss of value most fairly be distributed over the years? It can be shown that this is secured by following the theory that a steady aggregate of annual fixed charges is a normal economic phenomenon, or rather would be in the absence of fluctuating cost of materials and labor. Before that theory is presented, however, it is best to approach the subject by looking at some of the older attempts to make compensation for depreciation (defined as "retirance" in the previous article) follow the loss of value.

### Maintenance Plan

The oldest and the simplest attempt to saddle renewals on customers was by charging them for all the repairs and renewals of the year. This had the unfortunate effect in some cases of placing an extreme burden of retirance on some years and practically none on others, with the result that rates were too far below true cost at the start and the company was in financial straits at the end. Such was particularly apt to be the situation in those utilities where the property items were long lived—like water and gas works. It has worked out best in the case of utilities whose plant was composed of a multitude of parts of short life—like telephone systems and some railroads, though the latter have to resort to "expedients" when expensive long-lived fixtures like stations and bridges give way.

It is hard to distinguish between upkeep of old property and new extensions, so that one result of the direct-replacement or maintenance scheme in some cases has been to make additions out of earnings. A certain amount of such manipulation often may be sanctioned, but too much of it hides the true cost of service and may cause a company's stockholders to earn unduly on property which the customers and not the investors paid for.

The actual value of an established property in equilibrium administered after this scheme is only from 60 to 85% of the investment (plus appreciation). This 15 to 40% depreciation is lost to the company, according to the Knoxville decision (cited on this point in the previous article), through neglect to collect. The plan gives no adequate knowledge of the annual depreciation and it is assuming less and less importance each year.

### Appraisal Plan

A second plan that has been tried is the subtraction from earnings of sums which an examination of the property shows represent the loss in value. This is better in theory than in practice—due to certain human limitations and to one inherent defect. Changes due to depreciation are not well disclosed by annual examinations because of but slight changes in appearance from year to year—differences which, however, become more noticeable as the period between appraisals lengthens. Then the mind of the appraiser may change from year to year, or, more likely perhaps, the appraisers themselves may change and bring a radical change in standards of comparison.

This sort of depreciation levy must be dangerous, in view of the Knoxville decision. It gives weight largely to superficial evidence of past deterioration, while the worth of the property, from the point of view of the integrity of investment, has been further impaired by the accrued liability for renewals on account of probable obsoletion. It will not do to say that the depreciation compensations secured from rates relate absolutely to the past loss—to what can be seen to have definitely happened. Retirements of obsolete equipment must come in the future, it is true, but when they do come they must be paid out of past earnings or future economies, to accord with the Knoxville decision. This means that the utility has an increasing liability each year for obsolescence and that each year something must be secured to compensate for the annual increment of this liability.

### Straight-Line Scheme

The most obvious way of distributing the burden of retirement over the life of service is to divide the cost by the years of life and set out the resultant quotient from each year's earnings. Such money can be held by the utility owner as he sees fit against the day of replacement. If the accumulated reserves and the time passed be plotted as a mathematical graph or "curve," the form will be a straight line of course—hence the engineer's term "straight-line scheme" which has mystified most laymen and some attorneys.

One difficulty is that in spite of a superficial plausibility in the straight-line plan, there is no logical reason to expect that simple depreciation necessarily accumulates in direct proportion to the age—that the value of a machine is half gone at half its expected life. Indeed when property having a very long life, like cast-iron pipe, which is good for 60 to 100 years, is considered—the value is seen to be not inversely proportional to the age. In fact the pipe at 30 years is worth 80% instead of 50%—because of the importance of interest element in affecting worth. Moreover, during the early period of operation, the load is apt to be light and the unit costs high anyway,

*Advance publication of parts of a chapter from a forthcoming book, "Public Utility Rates," to be published by the McGraw-Hill Book Co. Copyright; rights reserved.

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so that the development of the business would be hampered by large retirance factors in rates.

However, on the other hand, if the utility property largely consists of a great number of short-lived items, as is the case with most telephone systems, railroads and some electric railways, then the straight-line scheme has an attractive simplicity and the discrepancy between actual depreciation and retirance secured cannot be appreciable. Straight-line schemes here have an advantage over the actual-renewal or maintenance basis for utilities whose properties may not show anything approaching equilibrium between depreciation and maintenance.

### Sinking-Fund Annuity Plan

The most popular scheme of computing the annual depreciation of a property item is to consider that it follows the growth of a sinking fund sufficient to extinguish the cost at the end of the probable life. Now, as is well known, a sinking fund grows through the payment to it of an annuity or annual contribution and by the investment of the sums so contributed, so that there is an annual sum for interest which is retained in the fund. The annuity or annual contribution is made of such size that it will, if invested at compound interest, with the interest accumulations equal the cost of the property item after a given number of years, representing the life of such item. Therefore, in order that the annual retirances which must come from the rate payers may closely approximate the annual depreciation increments, *they must in each year equal the annual contribution to a sinking fund plus the accumulations of interest,* and this furnishes the basis for the Stearns, or equal-annual-payment plan, subsequently described.

The general practice, however, is to include directly in the sums to be earned as retirances only the annuity or annual contribution to the sinking fund, which is a much smaller sum; and if the discrepancy were not provided for in the earnings somehow, a great injustice would be done the owner, for it is only through the rates that the entire depreciation can be made good and the investment kept unimpaired. This discrepancy between annuity and required retirance, in practice, is compensated for by allowing the owner of the property to include in rate-basis worth the undepreciated value of the property—even though it may have lost considerable value through depreciation. Part of what should have been accounted for as direct retirance is recovered under guise of interest.

It is a serious defect of the sinking-fund-annuity plan, in view of the principles underlying the Knoxville decision, that it is necessary in order to preserve equity to use the undepreciated value of property contrary to the requirements of law as interpreted in this famous case. There is danger that the law, as it stands interpreted so far, may prevail against equity for the older utilities working with sinking-fund annuities as pseudo-retirances. The injustice will come to those concerns which in good faith have used sinking-fund annuities to provide retirance. The situation is brighter for those who have been constrained by government to form sinking funds, for they may charge that confiscation has begun, unless they receive full value. The remedy for these dangers seems to be the abandonment of the sinking-fund annuity as the measure of retirance and the substitution of the larger sum numerically equivalent to a sinking-fund annuity plus the interest accumulations of the year.

A good part of the popularity of the sinking-fund-annuity plan has possibly been due to a vague feeling that somehow the depreciation was being cared for adequately at much less expense than by any other scheme. Such a view savors a bit of the old "some-thing-for-nothing" ideas that are so persistent and so often attractive.

This plan carries with it, in some cases and always in some people's minds, the implication of a distinct reserve fund invested in outside securities. However, in the great majority of cases, seemingly, the allowances so secured are put into the property in place of money that would have to be raised from outside sources. Investing reserve funds inside the business complicates the scrutiny of accounts and operating results, but it tends to reduce slightly the cost of service or product—something which is desirable.

No matter whether the retirance funds are invested inside or outside of the business, for the scrutiny of rate facts it seems essential to remember that reserves made up of sinking-fund annuities must earn for their own aggrandizement in order to provide full amortization. Therefore they are not to be regarded as free capital in studying the business, no matter how the owner chooses to handle them in the interests of daily operation.

It needs to be emphasized perhaps that in the great majority of concerns, up to the present, the sinking-fund method of figuring retirance in rates has been merely an attempted process of arriving at a fair and proper burden on the customers. The money once secured has been looked on simply as company property with no strings hitched to it. Unless the degree of regulation is severe, there is not apt to be dictation as to how the retirance moneys shall be invested. The public is protected when the utility uses these repaid moneys in well-defined and safe ways.

The complication and confusion of thought introduced into the scrutiny of utility business by the "sinking-fund" plan have led some to go back to the scheme of directly apportioning the cost of an item over the expected years of life, but not uniformly as in the regular straight-line scheme. Instead they have variously decreased it in the early years and increased it toward the end of the expected-life period of the piece of equipment in question. Usually this has been done arbitrarily and empirically.

### Annual Cost of Service and Actual Depreciation

It is not mere age, nor yet service-ability drop that discloses annual depreciation, nor it is general appearance; but it is reasonable to expect that there should be some fairly logical basis of computing the probable annual real decrement. If the annual depreciation be assumed to start high, then the early retirance must be heavy and in the later years light; the fair value (rate basis, Knoxville-case standard) of an item would be low in later years and the fixed charges (interest and retirance) would greatly fluctuate. If now operating costs have not risen (excluding the effect of rise in price of labor and materials) and the service is well maintained, steady fixed charges may be regarded as a normal economic phenomenon. Fluctuation of service cost would be due to fluctuating cost of labor and supplies. That is to say, given a probable life of equipment where the fixed charges are large in proportion to the operating costs and where the deterioration or inadequacy will not seriously change the operating costs until very near the expected time of retirement, the real

annual depreciation is such that the fixed charges (interest and retirance) continue steady year after year.

For example, assume that a water pipe costing new $1,000 and having an expected life of 50 years had been in use 25 years. The interest at 6% and retirance would be for the first and twenty-fifth year, straight-line plan:

| | |
|---|---|
| 1st year interest | $60.00 |
| 1st year retirance | 20.01 |
| 1st year fixed charges | $80.00 |
| 25th year value | 500.00 |
| 25th year interest | 30.00 |
| 25th year retirance | 20.00 |
| 25th year fixed charges | $50.00 |

If it were assumed that there was no depreciation up to 25 years, as the pipe was giving good service, the comparison would be:

| | |
|---|---|
| 1st year interest | $60.00 |
| 1st year retirance | ..... |
| 1st year fixed charges | $60.00 |
| 25th year value | $1,000 |
| 25th year interest | 60.00 |
| 25th year retirance | 40.00 |
| 25th year fixed charges | $100.00 |

Following sinking-fund computations, the same pipe would show these figures:

| | |
|---|---|
| 1st year interest | $60.00 |
| 1st year retirance | 3.44 |
| 1st year fixed charges | $63.44 |
| 25th year retirance fund | 188.97 |
| 25th year value | 11.08 |
| 25th year interest | 8.66 |
| 25th year retirance (on $811.03) | 14.78 |
| 25th year fixed charges | $63.44 |

It is obvious that the $80 and $50 given by the straight-line plan for fixed charges during the first and 25th year and the $60 and $100 given by the inspection plan are extremely abnormal and uncommercial, while the $63.44 for both years by sinking-fund computations is economically desirable and reasonable.

Where the operating expenses go up materially due to the deterioration of the equipment, then the depreciation increases more rapidly than otherwise and may approach the straight-line basis, as shown later.

### "Equal-Annual-Payment" Scheme for Computing Retirance

An ingenious and scientific plan has been developed by Frederic P. Stearns for his engineering practice. (The simpler elements were discussed in 1914, in the progress report of the special Committee of the American Society of Civil Engineers on Valuation for Utility Rate Making.) It may be regarded as a modification of the straight-line plan, but with the annual allowances fixed in such a way that the aggregate of dominant factors in rates would tend to be constant year after year.

The calculations leading to equal annual fixed charges in the preceding example were spoken of as "sinking-fund computations." They follow the standard sinking-fund tables as to the amount of depreciation in the property at the beginning of the twenty-fifth year, though the amount of retirance adopted for the twenty-fifth year is not the sinking-fund annuity but the increase in the amount of the sinking fund during the year, consisting of annuity plus interest accumulations. When the sinking-fund computations are used in this way, the equal-annual-payment scheme of compensating for depreciation is evolved. As each year's retirance by the equal-annual-payment plan is equal to the annuity under the sinking-fund plan, plus the amount of the interest accumulations of the sinking fund during the year, the larger sum thus represented by the equal-annual-payment plan is the sum which the company is entitled to earn as an offset to the depreciation of its property to keep investment intact.

It may seem at first that the equal-annual-payment plan, providing as it does a larger retirance for each year after the first than the annuity of a sinking fund, would be opposed to the interests of the rate payers and would give larger earnings to the company. This, however, is not the case when both systems are applied in an equitable manner. The company should be permitted to earn a retirance equivalent to the amount of depreciation; and if the retirance is figured to be the inadequate sum represented by the sinking-fund annuity alone, there must be a further allowance from the rate payers to cover the interest accumulations of a sinking fund during the year. As shown already, it commonly masquerades with interest on full undepreciated value of plant. The assumption, contrary to the facts, that the property has not depreciated in value, is wholly for the purpose of making up for the inadequacy of the retirance when it is assumed to be equal to the sinking-fund annuity alone.

By the equal-annual-payment plan substantially the same results can be secured as with the sinking-fund annuity and full-value scheme—but quite in harmony with the Knoxville decision. The equal-annual-payment plan will be seen to be the simplest case of what the writer has called for convenience a group of "concave-curve" plans all closely related to it and all springing out of complicated practical conditions discussed in a later paragraph.

Retirance, figured by this plan, is declared not to be in any sense a reserve. It is an immediate and direct compensation for property value lost by deterioration and liability incurred for retirement of equipment. The retirance is immediately available for canceling obligations or, what is equivalent, for reinvestment in replacements, additions, improvements, etc. When retirances are so reinvested they enter rate-basis worth on a par with extensions paid for by fresh accessions of capital.

Interest is allowed only on the diminished worth (unreturned investment) of each item; where the retirance sums are reinvested, those new property items so purchased earn like all the other items, and retirance is collected each year for them also. Obviously, the annual interest on unrepaid investment in each item of property goes down steadily, but the retirance aggregate goes up correspondingly. The annual payments for retirance and interest on continuing investment then can have a constant annual aggregate when the rate of interest and the rate for retirance computations are the same.

### Depreciation Under Increasing Operating Costs

Where the cost of operation goes up materially because of the deterioration of the equipment, then of course the equalization of annual fixed charges alone is not a proper criterion. Rather it would appear to be proper to hold that the sum of fixed charges and of operation-cost increase should remain constant. Under these conditions the real depreciation may more nearly approach the unmodified straight-line apportionment. It may disclose a depreciation more rapid than that given by the straight-line scheme for the length of life first assumed to hold.

For instance, take the case of a small water-works pump. Suppose that it was a new departure in design and was expected to have a life of 10 years; suppose that in service it was found that slip and increased friction

increased the cost of operation $4 each year. (This is a hypothetical situation purposely taken for illustration.)

To find the actual depreciation under these conditions, the capitalized excess cost of operation is deducted from the figures for nominal value and considered as repaid to the investor. The remaining value is repaid during the 10 years according to equal-annual-payment plan; the depreciation (and the retirance) is the sum of each year's capitalized excess cost and the other annual factor. The computations are shown in the accompanying tables.

When the output has decreased with age, the unit cost has increased. The multiplier is the reciprocal of the decreased capacity—if the output is only 0.9 of the initial then the unit cost is 1.11 times the initial value. The total cost of the original output, if the deficiency was made up by other machines of similar type, would be increased by use of the same multiplier; that is, an excess cost results which can be studied exactly as was the extra cost of operation. If the annual operating expense of the hypothetical pump already noted was, say, $800, a gradual drop of capacity, without increase of gross operating expense, to 95.3% in these 10 years would mean an increase in excess cost of 5%, or $40. Table 2 therefore applies.

TABLE 1. ANNUAL RETIRANCE AND FIXED CHARGES BY THE EQUAL-ANNUAL-PAYMENT PLAN

| End of Year | Diminished Value | Interest | Annual Retirance (or Deprec'n Increment) | Aggregate Retirance (or Depreciation) | Interest plus Retirance |
|---|---|---|---|---|---|
| 0 | $1,000.00 | | | | |
| 1 | 924.13 | $60.00 | $75.87 | $75.87 | $135.87 |
| 2 | 843.71 | 55.45 | 80.42 | 156.29 | 135.87 |
| 3 | 758.46 | 50.62 | 85.25 | 241.54 | 135.87 |
| 4 | 668.10 | 45.51 | 90.36 | 331.90 | 135.87 |
| 5 | 572.32 | 40.09 | 95.78 | 427.68 | 135.87 |
| 6 | 470.79 | 34.34 | 101.53 | 529.21 | 135.87 |
| 7 | 363.18 | 28.26 | 107.61 | 636.82 | 135.87 |
| 8 | 249.10 | 21.79 | 114.08 | 750.90 | 135.87 |
| 9 | 128.18 | 14.95 | 120.92 | 871.82 | 135.87 |
| 10 | ..... | 7.69 | 128.18 | 1,000.00 | 135.87 |

TABLE 2 ANNUAL RETIRANCE AND FIXED CHARGES FOR EQUAL FIXED-AND-EXCESS COSTS: RISING OPERATING EXPENSE OR DECREASING CAPACITY

| End of Year | Excess Operating Cost | Total Capitalised Excess Repaid | Sinking-Fund Increment | Annual Depreciation or Retirance | Aggregate Retirance or Depreciation | Diminished Value | Interest on Value | Retirance, Interest and Excess Cost |
|---|---|---|---|---|---|---|---|---|
| 0 | ..... | ..... | ..... | ..... | ..... | $1,000.00 | ..... | ..... |
| 1 | $4.00 | $66.67 | $25.29 | $91.96 | $91.96 | 908.04 | $60.00 | $155.96 |
| 2 | 8.00 | 133.33 | 26.81 | 93.48 | 185.44 | 814.56 | 54.48 | 155.96 |
| 3 | 12.00 | 200.00 | 28.42 | 95.09 | 280.53 | 719.47 | 48.87 | 155.96 |
| 4 | 16.00 | 266.67 | 30.12 | 96.79 | 377.32 | 622.68 | 43.17 | 155.96 |
| 5 | 20.00 | 333.33 | 31.93 | 98.60 | 475.92 | 524.08 | 37.36 | 155.96 |
| 6 | 24.00 | 400.00 | 33.85 | 100.52 | 576.44 | 423.56 | 31.44 | 155.96 |
| 7 | 28.00 | 466.67 | 35.88 | 102.55 | 678.99 | 321.01 | 25.41 | 155.96 |
| 8 | 32.00 | 533.33 | 38.03 | 104.70 | 783.69 | 216.31 | 19.26 | 155.96 |
| 9 | 36.00 | 600.00 | 40.31 | 106.98 | 890.67 | 109.33 | 12.98 | 155.96 |
| 10 | 40.00 | 666.67 | 42.73 | 109.40 | 1,000.07 | —0.07 | 6.56 | 155.96 |

TABLE 3. ANNUAL RETIRANCE AND FIXED CHARGES FOR EQUAL FIXED-AND-EXCESS COSTS: INCREASING OPERATING EXPENSE WITH DECREASING CAPACITY

| End of Year | Excess Cost | Total Capitalized Excess Repaid | Annual Depreciation (or Retirance) | Aggregate Retirance | Diminished Value | Interest on Value | Retirance, Interest and Excess Cost |
|---|---|---|---|---|---|---|---|
| 0 | ..... | ..... | ..... | ..... | $1,000.00 | ..... | ..... |
| 1 | $8.00 | $133.34 | $133.34 | $133.34 | 866.66 | $60.00 | $201.34 |
| 2 | 16.00 | 266.66 | 133.34 | 266.66 | 733.34 | 52.00 | 201.34 |
| 3 | 24.00 | 400.00 | 133.34 | 400.00 | 600.00 | 44.00 | 201.34 |
| 4 | 32.00 | 533.34 | 133.34 | 533.34 | 466.66 | 36.00 | 201.34 |
| 5 | 40.00 | 666.66 | 133.34 | 666.66 | 333.34 | 28.00 | 201.34 |
| 6 | 48.00 | 800.00 | 133.34 | 800.00 | 200.00 | 20.00 | 201.34 |
| 7 | 56.00 | 933.34 | 133.34 | 933.34 | 66.66 | 12.00 | 201.34 |
| 8 | 64.00 | 1,066.66 | 66.66 | 1,000.00 | 0.00 | 4.00 | 134.68 |
| 9 | 72.00 | 1,200.00 | ..... | ..... | ..... | 0.00 | ..... |
| 10 | 80.00 | 1,333.34 | ..... | ..... | ..... | ..... | ..... |

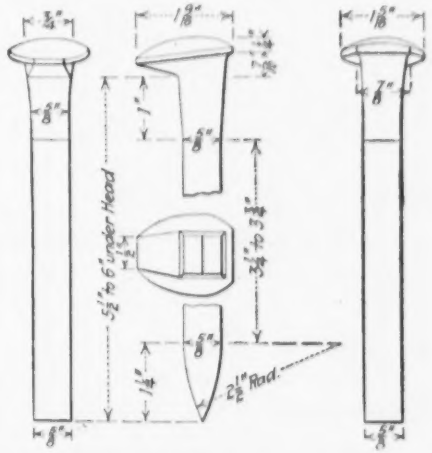
Should the two actions be combined, then the result would be as in Table 3. The only change over Table 2 is that caused by doubling the excess cost, and capitalized excess cost. This amounts to the original cost of the $1,000 item by the eighth year, so that there is no need of attempting to retire the item by introducing any equal-annual-payment-plan factor.

In theory the excess costs may rise less regularly than shown, but attempts to find how they go probably are no closer estimates than assuming a uniform increase.

## New Track Spike

The modified design of cut spike or drive spike for railway track, shown in the accompanying drawing, has been proposed by a committee of the American Railway Engineering Association in connection with its standard specification for spikes.

In this design, as described in the "Proceedings" of the Association for 1916, the head is designed to take the blow of the hammer directly over the axis of the spike, and thus minimize the damage to spike heads and the danger




IMPROVED DESIGN OF TRACK SPIKE

of breaking off the head during very cold temperatures. The tilting downward of the nose gives a stronger construction, and assists in giving an easier clearance in making the spike. It also permits the pulling of the spike more readily with the clawbar.

The reinforcement is symmetrical. That on the back of the neck was used originally (as it now is with many roads) to force the spike forward against the base of the rail when driving. The reinforcing of the front of the neck is in order to give additional metal to withstand rail wear and necking of spikes.

**The Cost of Railway Passenger Terminals** in large cities is emphasized in an argument made by Henry W. Bikle, Assistant General Counsel of the Pennsylvania R.R., before the Pennsylvania Public Service Commission on Nov. 24, in the matter of fares for suburban passengers entering Broad St. station, Philadelphia. The railroad proposed to establish a minimum rate of 10c. per passenger for 50-trip tickets to all stations within seven miles of the Broad St. station. Mr. Bikle stated that the actual cost of handling each passenger at Broad St. station, without taking into account any haul over the road, or any interest on the railroad company's investment in the property, has been found to be 8c. In addition to this cost of handling the passenger in the terminal, there must be added the cost of operating the road through the suburbs. Short-distance commuters using the Broad St. station ride over some of the most costly stretches of railroad in the world. Portions of these lines represent investments of millions of dollars per mile, because they are built in the heart of a great city where rights-of-way are expensive and construction most difficult and costly. Travelers who use such expensive stretches of track should in fairness pay somewhat higher rates per mile for the service than those carried over track which represent ordinary expense. In the handling of suburban traffic also there is a great deal of empty car movement necessary.[1] A suburban train leaving Philadelphia, for example, must have cars enough to accommodate the passengers who wish to ride to the nearest station. These cars even though half filled or empty, however, must be hauled to Paoli or Westchester, as it is not feasible from an operating point of view to drop off cars en route.

# New Municipal Dock at St. Louis

The City of St. Louis recently awarded a contract for the construction of the first section of a municipal dock to be built at the foot of North Market St. Aside from being one of the first large municipal docks on the middle Mississippi, there are a number of unusual features in connection with the location and construction.

At the point where the dock is to be built the harbor line is a considerable distance out from the present shore line, so that all the construction must be done in water.

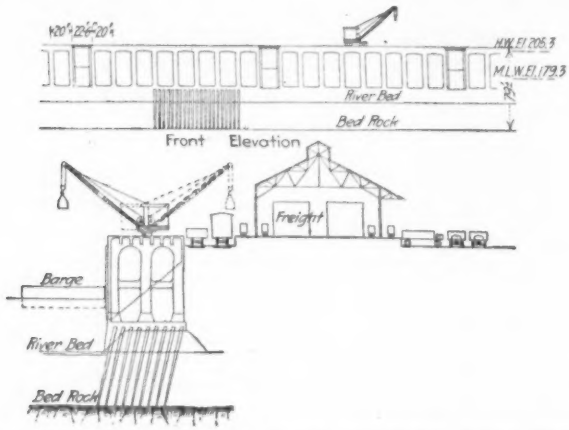



FIG. 1. GENERAL LAYOUT OF CONCRETE DOCK FOR MUNICIPAL DOCKS AT ST. LOUIS

The range of water in the Mississippi is about 42 ft., and the dock had to be designed for satisfactory operation at all stages within these limits. The main features of the design are shown on the accompanying drawing, which is taken from the plans.

The general characteristics of the dock can best be described by the consecutive order of steps that will be taken during construction. Plank mattresses will be woven on a barge held in place by cables, and sunk by weighting down with riprap. Foundation piles will be driven at a batter of 2½ in. horizontal to 12 in. vertical, which will place them parallel with the resultant of the weight and bank pressure, thereby eliminating all tendencies of the dock to slide forward toward the river. The tops of the piles will stop at zero stage on St. Louis gage.

As the river bed at the dock site is about 12 ft. below zero, the upper 10 ft. of the foundation piles will be surrounded by heavy riprap, extending up to 2 ft. below zero on the gage, and leveled off on the top to receive a monolithic slab of concrete 4 ft. thick, covering the entire area of the dock site.

On top of this footing slab the dock structure will consist of a reinforced-concrete viaduct 36 ft. wide, 40 ft. high, bents 20 ft. c. to c., spans T-beam and slab construction. At the back or land side of the dock wall a curtain wall or concrete bulkhead will extend down 12 ft. below the dock floor for the entire length of the structure, and below that the fill behind the dock wall will be permitted to slope under the dock to meet the footing slab at the water's edge. This slope will be heavily riprapped.

On the dock there will be placed eight 80-lb. T-rails, each rail spaced a standard gage distance of 4 ft. 8½ in. from the next rails, in order that locomotive cranes or cars may be placed in any one of a number of positions on the dock floor. Although a locomotive crane is shown on the plan, that is intended as merely the beginning of the equipment to be provided. The rails in the dock floor will be arranged to accommodate overhead traveling gantry cranes, as well as locomotive cranes, and in addition the dock structure will permit the installation of numerous vertical elevators and inclined conveyors under the dock floor.

As now designed the structure will be built of five units each 160 ft. long with spaces about 22 ft. wide between the units. In these four spaces there will be installed elevators about 18 ft. wide and 25 ft. long, with a capacity sufficient to handle the largest automobile trucks from street level to boats, or vice versa, in addition to which, of course, the elevators can be used for many other purposes.

Attention is now being given to the suggestions of some steamboat men that additional elevators be installed in the dock face at intervals of 60 ft. instead of 180 ft. as now contemplated.

The dock wall is the cheapest permanent structure that has yet been considered. For a length of 890 ft. a bid of $187,250 was received—that is, about $205 per lin.ft.—which, however, includes the cost of two timber dikes and a timber fender, so that the actual cost of the concrete structure will be considerably less than $200 per running foot.

This does not include the filling or tracks for warehouses behind the dock, which will be accomplished by

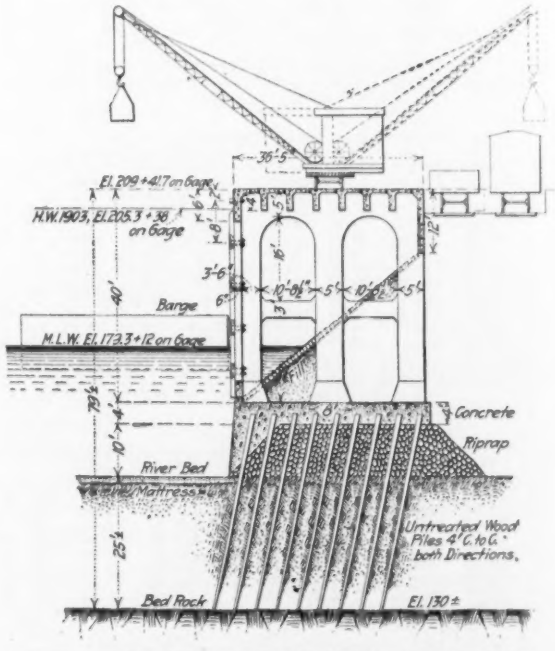



FIG. 2. DETAILS OF DOCK WALL AT ST. LOUIS MUNICIPAL DOCKS

other contracts and arrangements. It is proposed to get as much fill as possible by sedimentation from the river, induced by temporary dikes that will be constructed above the dock, and to get as much fill as possible on top of that sedimentation from the city refuse.

This work is to be done under J. A. Hooke, Director of Public Utilities for the City of St. Louis. C. E. Smith, of St. Louis, is Consulting Engineer for the Department of Public Utilities.

## Street-Railway Track Without Spikes or Bolts

A street-railway track in which no spikes or bolts are required as fastenings has been introduced by the United Railways Co., of St. Louis, Mo., in the reconstruction of the Grand Ave. line between Lafayette Ave. and Arsenal St. The new track (of 4-ft. 10-in. gage) has 6-in. 100-lb. T-girder rails on steel ties 6 ft. 8 in. long, weighing 100 lb. each and embedded in concrete. These are spaced 4 ft. c. to c., with an extra tie at the joints, which are laid opposite. The joints are welded electrically. The track is paved with granite blocks grouted with cement. Information as to this track construction has been furnished to us by C. L. Hawkins, Engineer of Maintenance-of-Way, United Railways Co.

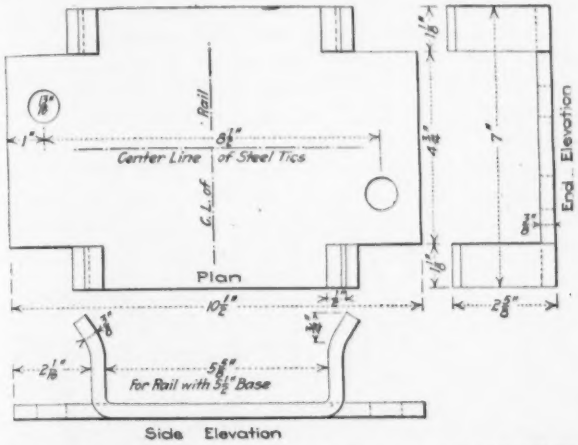



FIG. 1. STEEL TIE-PLATE WITH LUGS TO BE HAMMERED DOWN ON THE RAIL AS FASTENINGS

The ties are of the Carnegie type, of H-section, and each has riveted to its top flange a pair of Vaughn steel tie-plates 7x10½ in. This work is done at the railway company's shops. The plates, shown in Fig. 1, are of soft steel, ⅜ in. thick. At each corner the plate is slit, and the strips are bent upward, forming four upstanding lugs 1⅛ in. wide and about 2 in. high. When the rail is in place, these lugs are hammered down upon its base. Fig. 3 shows how this is done, a spiker with ordinary spike maul striking another maul that is held on the lug. A third man holds up the tie with a bar in the usual way.

Since 1912, these tie-plates and fastenings have been used on white-oak ties with 100-lb. T-rails (A. R. A. section) in paved track with concrete foundation. On some pieces of track where the paving was not laid the exposed tie-plates and fastenings appear to be as tight as when placed originally. On sections of track opened for installing special work, etc., the rails are found to be tight, and the condition of the pavement in general indicates that there is no appreciable loosening. The specifications require that a plate or specimen must bend 180° cold, flat upon itself, without cracking on the outside of the bend.

To make room for the new steel ties, alternate wood ties are removed. Many of these are pulled out when the old rails are broken with a rail-breaking machine. Mr. Hawkins states that in a large amount of repair work which has been done on the old track, the old hook-head spikes were removed and screw spikes installed to prevent the vibration of the rail and the destruction of the pavement. Almost all the ties where screw spikes were used are removed when the rail is broken. Other ties are removed by picks and bars.

To assist in the removal of ties, holes are drilled with compressed-air drills on one side of the ties that are to be removed, and small charges of dynamite are placed in these holes. These are fired after a flat-car provided with hanging sideboards reaching to the street pavement has been pulled over the holes to be fired. This dynamiting loosens the concrete so that the labor required for the entire removal is greatly reduced.

On some other work done during 1916, trenches were cut in the concrete (between the old wood ties) to receive the steel ties. Fig. 2 shows the concreting train used in the reconstruction work described above. To reduce the traffic over this work, the cars of some routes were turned back on reaching Grand Ave.

The old track laid in 1907 had 112-lb. 9-in. Trilby grooved-girder rails on cypress ties 6x8 in., 6 ft. 8 in. long, spaced 2 ft. c. to c. on a concrete base. Steel tie-plates were used, and the rails were fastened with hook-head spikes, while tie-rods were placed at intervals of 6 ft. Cast-weld rail joints were used, and the tracks were paved with granite blocks.

As to the durability of ties embedded in concrete, the cypress and oak ties taken out of the concrete track foundations laid at various places during 1905 and 1906 show that the concrete keeps the ties water soaked. No rotting has been found. Tests made last year on ties to determine the distance from old hook-head spike holes

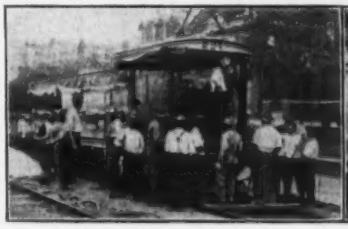


FIG. 2. CONCRETING TRAIN AT WORK ON ST. LOUIS RAILWAY TRACK

FIG. 3. HAMMERING DOWN TIE-PLATE LUGS

which would be required for satisfactory holding power of screw spikes, showed that the old ties were water soaked. When the spike was pulled out by the testing machine, water was squeezed out of the tie. The ties used on these tests had been taken out of a concreted track (laid during 1906) two days before the test was made.

⁂

**Reinstatement of Three Boston Engineers** in the Public Works Department of that city has been given further support by the action of a State Supreme Court Judge who has confirmed the reinstatement order of the lower court. It is expected that Mayor Curley will appeal to the full bench of the Supreme Court, in which case the final argument will be made in March, 1917. The engineers involved are Frank A. McInnes, division engineer in charge of sewer and water service, Storrs L. Durkee, superintendent permit department paving division, and Bliss W. Robinson, superintendent main drainage system. The decision of the lower court in this case was summarized on p. 45 and commented upon on p. 35 of "Engineering News," July 6, 1916. Of the 14 other engineers removed last January by Mayor Curley nine had been restored to subordinate positions in the city service by midsummer. An account of the decapitation of the 17 engineers was given on p. 193 and editorial comment was published on p. 184 of "Engineering News," Jan. 27, 1916.

# Cost Records of Monolithic Brick Pavements

By William Robert Paige*

*SYNOPSIS—Detail records are given of organization, material and labor costs on a paving job where the brick was laid directly on the green concrete.*

Carefully compiled cost records are an interesting feature of the monolithic brick pavement constructed by the writer at Marshall, Ill., as described in *Engineering News*, Nov. 23, 1916. The construction work was under the direct supervision of the writer, who had full charge of the inspection, and a very accurate account of the labor and materials used was kept each day, together with record of the amount of work done. The figures were carefully compiled and the results tabulated.

In keeping the account of labor costs the work was divided into three parts or sections—the mixing and placing of the concrete base and mortar cushion; the bricklaying, and the slushing or grouting. The overhead charges comprised the pay of a foreman, a timekeeper and a water boy, who were all allowed straight time. The water boy looked after the lights and barricades for the nights and Sundays and was paid for seven days' work. His time was figured for seven days and divided by six working days. The total overhead charges per day were added together and divided by three, charging each section with one-third of the cost.

The usual crew employed in mixing and placing the concrete and mortar cushion was 1 engineman for the mixer, 1 subforeman for placing and leveling the concrete and looking after the grade of the concrete, 4 gravel wheelers, 4 shovelers, 9 on the mixer and 3 mortar mixers. The engineman, subforeman and laborers were paid on a separate scale of wages. The exact time of the men and the number of square yards laid each day were kept. The cost per square yard was determined by the following equation:

$$\frac{E \times e + F \times f + L \times l + C}{Y} = \textit{cost of concrete per square yard for labor}$$

where

$E$ = Time of engineman in hours per day;
$e$ = Rate of wages per hour paid engineman;
$F$ = Time of subforeman in hours per day;
$f$ = Rate of wages per hour paid subforeman;
$L$ = Total time of laborers in hours per day;
$l$ = Rate of wages per hour paid laborers;
$C$ = One-third of total overhead charges;
$Y$ = Number of square yards of concrete laid per day.

The usual crew for bricklaying consisted of 2 brick setters, 12 brick carriers, 2 rollers, 1 sweeper and 1 batter. The brick setters were paid a different scale of wages from the laborers. The cost per square yard per day for laborers was determined by the following equation:

$$\frac{B \times b + L' \times l + C}{Y'} = \textit{cost of brick laid per square yard for labor}$$

where

$B$ = Total time of brick setters in hours per day;
$b$ = Rate of wages per hour paid brick setters;
$L'$ = Total time of laborers in hours per day;
$l$ = Rate of wages per hour paid laborers;
$C$ = One-third of the total overhead charges;
$Y'$ = Square yards of brick laid per day.

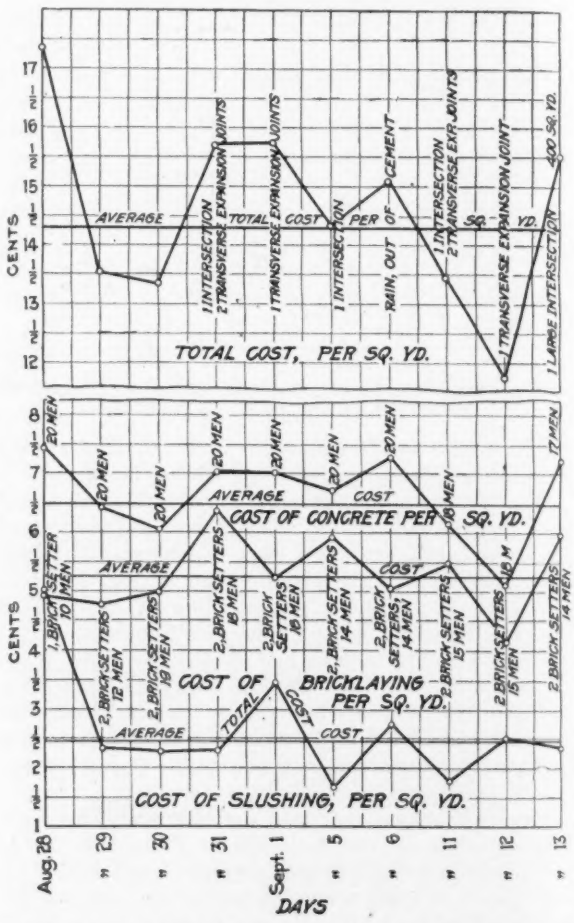



DIAGRAM OF COST OF MONOLITHIC BRICK PAVING AT MARSHALL, ILL.

The usual crew used for grouting was made up from the mixing crew or the brick crew. The cost of grouting was:

$$\frac{L'' \times l + C}{Y''} = \textit{cost of grouting per square yard for labor}$$

where

$L''$ = Total time of laborers in hours per day;
$l$ = Rate of wages per hour paid laborers;
$C$ = One-third of the total overhead charges;
$Y''$ = Number of square yards of slushing per day.

*Civil and Consulting Engineer, Terre Haute, Ind.

The actual time used in spreading sand over the completed pavement was also kept; but this time being small, the cost per square yard was determined for the whole amount of the pavement.

The results obtained on West Main St. are graphically presented in the accompanying diagram. The heavy vertical cross-section lines represent the different days, and the heavy horizontal cross-section lines the costs in cents. The lower resultant line shows the cost of grouting per square yard for labor, the next line the cost of bricklaying per square yard for labor, the next line the cost of mixing and laying concrete and mortar cushion per square yard for labor. The upper line represents the total cost of the pavement per square yard for labor. The horizontal line drawn through each curve represents the average cost per square yard for the entire work.

It is interesting to note the fluctuations in the cost of each day's work and to speculate on the probable causes. For instance, the first day's cost for all, except the bricklaying, was the highest. This was due probably to starting the monolithic work, which was entirely new to the contractor and to his men, and it took a greater portion of the day to become accustomed to this new method of laying the concrete. In the bricklaying, however, there was practically no difference in the methods used for monolithic over the ordinary sand-cushion pavement.

The second day the cost of the work was materially decreased, the most difference being in the cost of the slushing. The third day shows a slight decrease in the total cost, there being a slight decrease in the cost of the concreting, and a slight increase in the cost of the bricklaying, with a very slight decrease in the cost of slushing.

On the fourth day the cost increased, this being due to building the first street intersection. It will be noticed that the cost of bricklaying increased more than the other sections. The cost of laying the concrete also increased over the cost of the preceding day, being largely due to the fact that the intersection had to be shaped by hand. It will also be noticed that two transverse expansion joints were placed that same day. On the fifth day the total cost was very slightly increased, the cost of laying the concrete being slightly decreased and the cost of bricklaying being materially decreased, but the cost of slushing materially increased.

On the sixth day another intersection was placed, and the cost of bricklaying increased somewhat, while the cost of laying the concrete and slushing decreased, with the result that the total cost decreased over the preceding day. The day following, the total cost again increased, the cost of concrete and slushing increased, while the cost of bricklaying decreased. The only cause for this was that the work was stopped by rain and by shortage of cement.

On the eighth day another intersection and two transverse expansion joints were laid, with a decrease in the total cost of the pavement, with the bricklaying slightly increased. On the ninth day the total cost of the pavement reached its lowest point, and this is attributed by the writer to the almost perfect organization of the work and also to the fact that there were no intersections laid that day.

The last day the cost increased, due to a very large intersection and to connection with the old pavement. The slushing shows a variation, the cause of which probably was due to using first the mixer crew and then the brick crew.

A summary of the cost of West Main St. is given herewith:

Total number of square yards in the improvement ..... 5,841

| Labor Cost | Total | Per Sq.Yd. |
|---|---|---|
| Concrete base | $379.08 | $0.0649 |
| Bricklaying | 306.69 | .0525 |
| Slushing | 142.74 | .0244 |
| Sand top | 6.38 | .0011 |
| Total | $834.89 | $0.1429 |

Since the cost of labor, both skilled and unskilled varies at different times, the writer has compiled the results in time per square yard required for skilled and unskilled labor for the different divisions of the work. This is given in Table 1. The cost records for labor were obtained under very favorable conditions.

A record of the total amount of cement used for the concrete and for slushing was kept each day, and in this way the inspector was enabled to determine whether the correct amount of cement was used in the work. An account of the cement required in slushing was obtained for 4,131 sq.yd., and from this the average amount per square yard for the entire work was determined.

Table 2 gives the total amount of cement used, made up from the daily records, and shows its distribution on different portions of the work. Table 3 gives the quantities of different materials per square yard of paving.

TABLE 1. DISTRIBUTION OF TIME ON BRICK PAVING

| Total Paving Laid, 5,841 Sq.Yd. | Total Hr. | Hr. per Sq.Yd. |
|---|---|---|
| Concrete Base and Mortar Cushion: | | |
| Laborers | 1,346½ | 0.2305 |
| Engineman | 89½ | 0.0154 |
| Subforeman | 80½ | 0.0138 |
| Bricklaying: | | |
| Laborers | 1,035 | 0.1772 |
| Brick setter | 132½ | 0.0227 |
| Slushing, laborers | 512½ | 0.0877 |
| Spreading sand | 28½ | 0.0048 |
| Overhead time: | | |
| Timekeeper | ..... | 0.0171 |
| Foreman | ..... | 0.0171 |
| Water boy | ..... | 0.0171 |

TABLE 2. RECORD OF CEMENT USED IN BRICK PAVEMENT

| | Total Cu.Ft. | Cu.Ft. per Sq.Yd. |
|---|---|---|
| Slushing, 4,131 sq.yd. of paving | 594 | 0.144 |
| Slushing 5,841 sq.yd. (at 0.144 cu.ft.) | 840 | 0.144 |
| Total used on West Main St. work | 4,390 | |
| Used in base | 3,550 | 0.608 |
| Required for 4-in. base of 1 : 6 gravel concrete | .... | 0.500 |
| Required for ½-in. mortar cushion, 1 : 2 | .... | 0.094 |
| Required for concrete rest under expansion joints, each 24x3 in., 33 ft. long | .... | 0.004 |
| Total required in base, computed | .... | 0.598 |
| Excess cement used | 58 | 0.01 |

TABLE 3. MATERIALS USED PER SQUARE YARD OF BRICK PAVING

| | Cu.Ft. per Sq.Yd. |
|---|---|
| Cement in 4-in. base, 1 : 6 concrete | 0.500 |
| Gravel in 4-in. base, 1 : 6 concrete | 3.000 |
| Cement in ½-in. mortar cushion, 1 : 2 | 0.094 |
| Sand in ½-in. cement cushion, 1 : 2 | 0.188 |
| Cement for slushing, 1 : 1 | 0.144 |
| Sand for slushing ½-in. top covering | 0.188 |

**The Mississippi River Freight Line,** known as the Kansas City Missouri River Navigation Co., organized by the merchants and public spirited men in Kansas City in 1909 to operate a freight line on the Missouri River between St. Louis and Kansas City, handled a tonnage of over 18,000 tons inbound and outbound freight over the municipal wharf in Kansas City the past season. This is an increase of 10% over the inbound freight hauled in 1915 but there was a falling off in outbound freight due to the embargo and freight congestion on Eastern lines. This winter the company is trying an experiment in hauling freight between St. Louis and New Orleans instead of laying up its equipment. So far they have obtained all the freight they could handle. The transportation is done in weatherproof, fireproof steel barges and tow boats, and high-class freight is especially solicited. There is no other freight line on the Mississippi River competing for this class of freight.

# Tunneling in Firm Clay with Compressed Air

Using 15-lb. compressed air in firm clay at 76-ft. depth below water and working without a shield, an interesting piece of soft-ground tunneling has been done during the year. Though the tunnel is only 582 ft. long, its shell, or lining, is of mixed construction—concrete-block invert and brick arch, and in a few places mass concrete either with or without reinforcement. For a short portion of the tunnel this lining was laid up inside solid ring-timbering of wooden cants (sawed ring-segments); for most of the length, however, it was placed directly against the clay soil.

The tunnel crosses under the Cuyahoga River on the line of Central Ave., in Cleveland, Ohio, to carry a water main, and was built by the Water Department of the city by force account, under direction of C. P. Jaeger, late Commissioner.

Hazardous conditions surrounded the construction of the tunnel. They made trouble in sinking one of the two shafts, but by wise and lucky selection of the level at which the tunnel was to go through, the tunnel itself was kept out of all difficulties and was completed without serious incident or interruption.

Though the original intention was to excavate the tunnel at atmospheric pressure, compressed air was used throughout. It was not needed to hold out water, as the clay was absolutely tight and no sand streaks were encountered, but the air pressure acted to support the clay face and tunnel excavation until the lining could be placed.

## Nature of the Clay Soil

Slow squeezing of the clay under the pressure of superincumbent earth and water is a general phenomenon in tunneling in this soil in Cleveland. The rapidity and amount of squeezing vary with the softness or hardness of the clay. In the hardest clay the squeeze is practically negligible, and it has been found possible to let a 10- or 20-ft. length of tunnel and the face stand open, untimbered and unsupported, for days without noticeable change. A slight reduction in hardness, however, allows squeezing of considerable amount—several inches radially inward—to develop in the course of a day or less. Few places of this kind were encountered in the Central Ave. tunnel, and where they occurred the only difficulty produced was that a small amount of extra trimming had to be done when setting the lining blocks or laying up the arch masonry.

The tunnel is shown by Fig. 1 in profile, plan and section, but the drawing fails to show the stagger of the successive rings of lining blocks, which was employed to bond the brick arch to the concrete-block invert. All work was prosecuted from the east shaft.

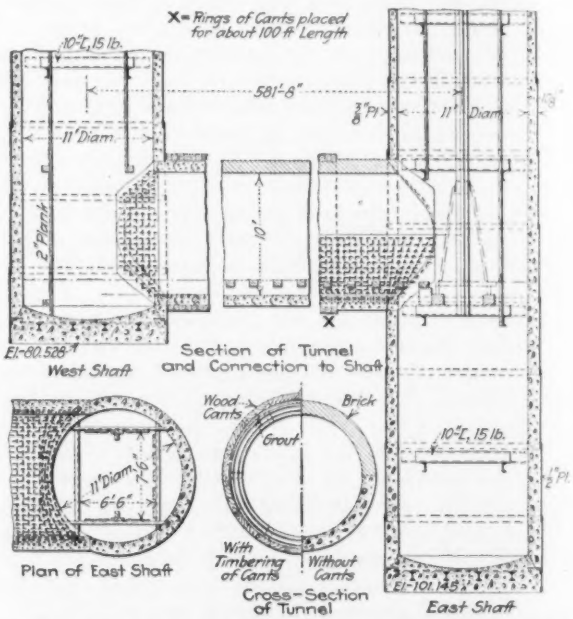
When the shaft was bottomed, an air lock was built on the top of the shell, and the eye of the tunnel was cut through under protection of 20 lb. of air. A small spring was struck near the shaft, but it was readily controlled by piping it to the shaft sump. Later it was grouted through the tunnel shell, starting about 30 ft. away from the shaft and working back.

As the drawing shows, the end portions of the tunnel are of mass concrete, reinforced to hold the nearly straight cheek pieces. Just beyond, the invert was made of mass concrete and the arch of brick; concrete blocks for the invert were not used at this stage because the blocks could not readily be passed into the tunnel through the shaft air lock and there was no erector crane to set them in place.

A lock was built into the tunnel itself at 35 ft. out; the shaft was fitted with an elevator and used thereafter as an open hoistway. The lock was formed by building two timber bulkheads with doors into 5-ft. gaps left in the lining; it had no steel shell, and for resistance to bursting pressure it depended on the bearing power of the surrounding clay. As the work got farther from the shaft, the pressure was held generally at 15 lb., with only occasional raises to 20 lb.

## Tunnel Excavation

The tunnel excavation was handled with semicircular draw-knives, as in all similar work in the Cleveland and Detroit clay regions. An exceptional feature was that a low bench was carried, the 12-ft. face being divided into a heading about 7 ft. high and a bench of about




CENTRAL AVE. PIPE TUNNEL UNDER CUYAHOGA RIVER AND SKETCH OF LINING CANTS

5 ft. The city's lake tunnel, of the same size, in similar material and under generally similar conditions, is run without a bench.

The force at the face comprised two excavators and two muckers in the heading and the same at the bench. Small cars, ⅓ cu.yd., were run on a track extending to the front edge of the finished lining. The muckers carried the slabs of clay cut down by the draw-knives back to this point, loading direct into the cars.

Excavation was ordinarily carried forward to such a length that a 12- or 16-ft. section of lining could be laid up. This would allow a succession of two lining shifts, respectively block laying and bricking.

For the first 100 ft. the excavation was lined with wood cants. These (see the drawing) were made of 6x6 and 4x6 material, to give rings of 6-in. radial thickness. Each is 2 ft. 8¾ in. long outside, sawed out of a stick 6 in. wide and the waste segment spiked on the

outside, as indicated in the sketch. Two ⅜-in. holes in each segment provide for spiking to the preceding ring. The wood was yellow pine and maple. A 10-in. spike ⅜ in. square with chisel point was used for the 6-in. cants, and a 7-in. spike for the 4-in. cants. They were driven by pneumatic hammer.

The original plan for the tunnel was based on putting the whole tunnel through at about 100-ft. depth (believed from the borings to be a safe level) without the use of compressed air. The temporary lining of cants was to be put in as the excavation proceeded; the permanent masonry lining was to be laid up in a single operation after excavation was completed. The conditions encountered in sinking the shafts, however, made it seem advisable to provide compressed air in the tunnel and also to line with masonry in short sections, so as not to leave open any long section of excavation. Under these circumstances and as the clay proved very firm and stable, the cants were abandoned after the first 100-ft. portion.

The stability of the clay was well shown at one period in February, 1916, when some difficulty with the bricklayers kept the excavation open two days, in which time the clay showed no squeeze or other trouble. The air pressure during this period was raised from the normal 15 lb. to 20 lb. to give additional support and later was slowly dropped back to 15 lb.

### Concrete-Block Lining

The interlocking concrete blocks used for the invert in this tunnel (but used for the entire ring in the city's new West Side lake tunnel) are of a new design, different from other concrete blocks hitherto proposed or used. They were evolved in the city water department under C. F. Schulz, Commissioner and Engineer until 1916. There are six blocks to the ring, or three for the invert of the Central Ave. tunnel. Each block is about 5 ft. long and weighs 1,200 lb.

In laying, the blocks were handled by a light steel erector gantry supporting a chain hoist. When the three blocks of the invert had been set—being held to true position partly by the interlock with the preceding ring and partly by blocking against the tunnel wall—the half-ring was grouted from springing-line level after packing the forward edge of the space between the block and the tunnel wall with clay.

At the end of a block-setting shift the wooden centers for the arch were put up, and the following shift laid the arch brickwork. The latter was carried up tight against the clay roof and sides, to avoid having to pack fill back of the masonry.

Making connection with the west shaft proved comparatively simple in spite of the many possible difficulties in bringing a tunnel under air pressure up against the steel shell of a shaft under atmospheric pressure, with shaft bottom only a few feet below. From a distance of 20 ft. away the tunnel was carried up against the shell of the shaft as a top heading. After the center line of the tunnel had been tied in with the center line of the shaft by resurvey, the bench excavation and the masonry shell of the tunnel were carried forward in very short sections until within about 6 ft. of the nearest point of the shell. Removal of the remaining portion of the bench was done very carefully, and the excavation, as fast as opened up, was lined with wooden cants (set outside the masonry line). The joints of the cants were also flushed with cement mortar so as to make the temporary lining tight against small air leaks while the pressure was kept on. Finally, when the temporary lining was completed up to the shaft shell, the air pressure in the tunnel was slowly reduced to atmospheric without trouble developing. Then the shaft shell was cut through, the concrete shaft lining was broken away, and the reinforced-concrete end section of the tunnel was placed.

### Danger from Gas a Factor

The known presence of gas occluded in pockets or disseminated in the clay and the actual striking of a quantity of gas in the east shaft made it necessary to take strict precautions against gas dangers. No open lights, matches or other sources of flame were allowed. A safety lamp (Koehler No. 2) was kept burning in the tunnel to give warning of the presence of gas. The air supply was unusually ample, to minimize the risk of gas accumulation even at the cost of a little extra coal.

John W. Dolman was engineer in charge of the tunnel work. Otto Scholz was in charge of surveys. Charles Vandevelde was superintendent.

The Central Ave. tunnel shafts were started in the fall of 1915. The tunnel was begun about the first of January, 1916, and was connected with the west shaft by the end of June, making six months for the tunnel work itself. On completion of the work, the springs in the bottoms of the two shafts were finally grouted, an operation that after some difficulties was successful. The tunnel at no time developed any leak; as previously mentioned, only the east end was grouted, and this simply because of a spring giving trouble while concreting was going on. The cost of the tunnel work, including shafts, was about $87,000

**The Price of Railway Supplies** has increased on the average about 60% during the past year, according to a circular just issued by the New York, New Haven & Hartford Railroad Co. to its employees. The circular enjoins upon all responsible for expenditures the need for the greatest economy in the use of material, and says: "Repairs should be made instead of complete renewals in all cases where practicable, even where under normal conditions it might be better to renew than to repair." The circular is accompanied by the following table showing the percentage increase in price of various important supplies during the 15 months from April, 1915, to July, 1916:

Increases Ranging from 10 to 35%

| | | | |
|---|---|---|---|
| Acids | 47 | Files | 70 |
| Air hose | 38 | Fuel oil | 42 |
| Angle bars | 33 | Fuses | 33 |
| Antimony (babbitt metal) | 42 | Gaskets, air-hose | 11 |
| Axles, car and tender | 48 | Nails, wire | 61 |
| Axles, driving | 30 | Pipe covering, all kinds | 33 |
| Axles, engine-truck | 63 | Pipe, galvanized | 17 |
| Belting, axle | 33 | Pipe, malleable | 59 |
| Belting, leather | 59 | Piston rods | 15 |
| Bolts, machine and carriage | 40 | Roofing | 17 |
| Bolts and nuts | 67 | Rope, manila | 61 |
| Brass (bar, sheet and spring) | 54 | Sheathing | 38 |
| Bridge timber | 44 | Springs, coil | 74 |
| Castings, gray-iron | 13 | Springs, elliptic | 51 |
| Chains, all kinds | 62 | Steel, bar | 77 |
| Claw bars | 30 | Tamping bars | 85 |
| Copper (bar and sheet) | 36 | Tamping picks | 26 |
| Couplers | 18 | Ties, cross | 13 |
| Crankpins | 12 | Ties, switch | 18 |
| Drills, all kinds | 64 | Tires | 55 |
| Ferrules, flue | 36 | Track spikes | 77 |
| | | Waste | 78 |

Increases Ranging from 85 to 250%

| | | | |
|---|---|---|---|
| Castings, brass | 107 | Steel, structural | 91 |
| Castings, steel | 107 | Steel, boiler | 226 |
| Cement | 86 | Steel, firebox | 195 |
| Gasoline | 118 | Steel, tank | 142 |
| Iron, bar | 95 | Track bolts | 115 |
| Journal bearings | 89 | Tubes, boiler | 94 |
| Rivets, boiler | 132 | Tubes, brass | 105 |
| Rivets, structural | 140 | | |

# Potash Becomes a Valuable Cement-Mill Byproduct

By Arthur C. Hewitt*

The great nuisance of portland-cement manufacture has been converted into an asset of the industry by the Cottrell fume-precipitation process[1]. This was first successfully applied to the suppression of dust at the cement plant of the Riverside Portland Cement Co., in California, but not until about the beginning of the European War was the real value of the recovered dust recognized. The first Cottrell plant built exclusively for the recovery of potash has recently been completed by the Security Cement and Lime Co. at its cement plant near Hagerstown, Md. This precipitation plant will be discussed in the appended paragraphs.

The Cottrell process of dust precipitation is very simple in theory, but somewhat difficult to put into practice. The scheme is simply to pass the dust-laden gases through an intense electrostatic field, where precipitation of the dust takes place upon the positive and negative electrodes of the electric circuit; this is essentially the same thing as takes place when a pith ball attached to the end of a thread is attracted to an electrified piece of rubber or glass. In putting this theory into practice, the difficulties encountered are principally in the generation, insulation and maintenance of the high-powered uni-directional electrostatic field. The insulation of the high-voltage circuit under temperatures ranging from atmospheric up to 1,200° F. is one of the things that calls for special consideration. The material finally used for this purpose is a so-called marble from Catalina Island, off the coast of California; many other materials have been tried, but none have given anything like the satisfaction that this has.

In the first studies the electrodes were plates between which the dust-laden gases passed, but these have been superseded by pipes with central wires. The pipes extend from a top header, which is the floor of an upper receiving chamber into which the kiln stacks discharge, to a lower header, in which is the ceiling of a chamber from which the cleaned gases are led off. Dampers control the entrance of gases to all or either half of the pipes, so that the idle electrodes may be periodically cleaned of the accumulating dust. For this both pipes and wires are mechanically rapped. The dust falls down into hoppers from which it is drawn into bags.

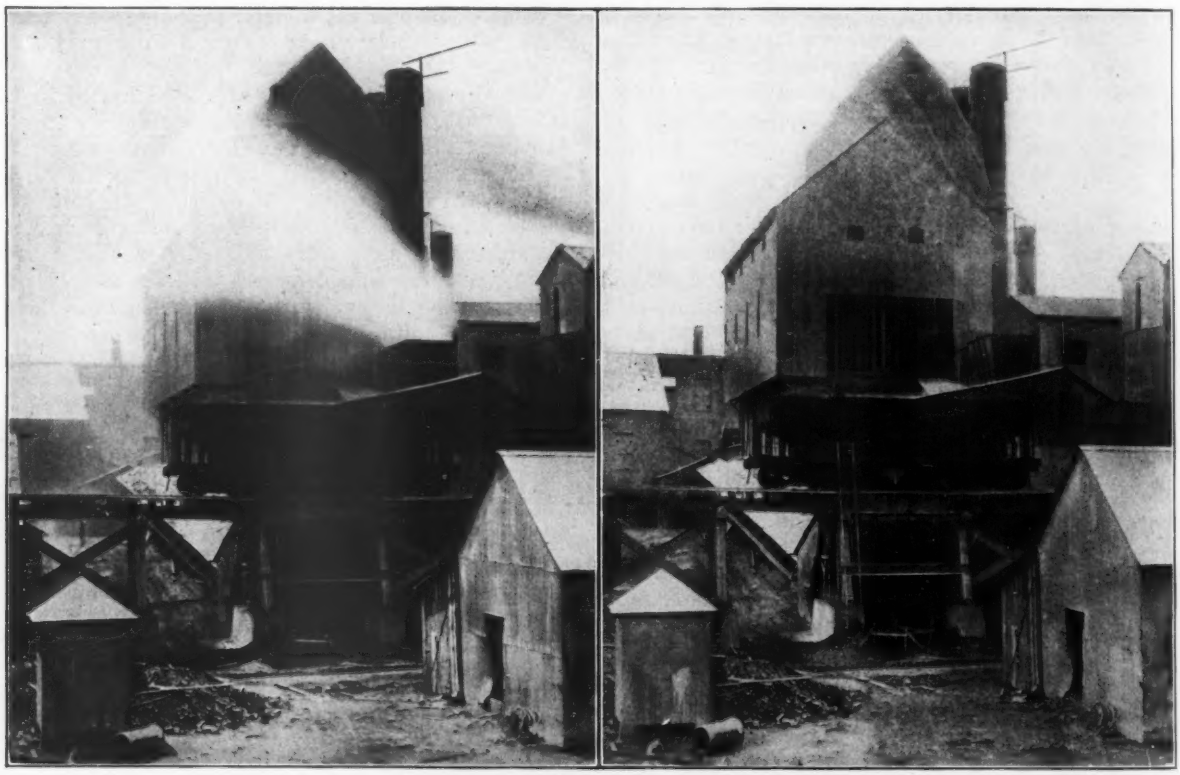


FIG. 1. CEMENT-DUST PRECIPITATION PLANT OF SECURITY CEMENT AND LIME CO.

At the left, kiln gas discharged with current off. At the right, current on; the only evidence of discharged gases is the slight hazing of the view of treater building and gooseneck flues

In November, 1915, John J. Porter, vice-president and general manager of the Security Cement and Lime Co., had experiments, tests and analyses made to determine what economic results might be secured if a Cottrell plant

*Chief Engineer, Security Cement and Lime Co., Hagerstown, Md.

[1]See "Engineering News," Oct. 26, 1911, p. 495; Oct. 31, 1912, p. 803; Oct. 9, 1913, p. 716.

were installed at the Hagerstown cement mill. The results were so promising that in December, 1915, the directors sent Mr. Porter to California to study the Riverside plant first hand. He spent a week there and on his return recommended that the Security company build a similar plant—but purely for the recovery of the valuable potash in the cement dust.

The directors accepted his report, and negotiations were begun with the Western Precipitation Co., owner of the patent rights for use of this process in cement plants. The plans were rushed through, the markets for material studied and the contract signed Feb. 8, 1916. The final drawings were received Feb. 23 and the contracts for steel and equipment let in the next few days. It was desired to push the work with all possible speed to secure maximum benefit of the war prices on potash but many construction difficulties had to be overcome, as noted later. The first trial run of one unit commenced June 15, and the other three units were completed by the middle of July.

### Design of Security Plant

The accompanying views and sketches show the general layout and more important details. It will be noticed that there are four treaters being used to precipitate the dust from five kilns. This is because two of the kilns are smaller than the others, and the gases from the two small ones are combined in a common flue. The large stacks connecting with the treaters are 7 ft. in outside diameter and are lined with 4-in. of firebrick to a point just below the Y-connection.

The treater building is 72x36 ft. over all in plan and 76 ft. high. In this building there are approximately 200 tons of steel; 50,000 rivets and 30,000 bolts were used in field erection alone. Practically the whole treater building is made up of light-weight angles and 10-, 12- and 16-gage plates. The treaters were designed for a gas velocity through the electrode pipes of 3.5 to 4 ft. per sec.

Louver dampers extend across the intake chambers at right angles to the roof, so that one-half of each unit can be closed off for shaking down the collected dust into the hoppers. The dampers are operated by compressed-air cylinders controlled from the ground level. The hoppers are connected by cross-passages to a longitudinal chamber of much the same general shape as the hoppers. Flop dampers (worked by compressed air) close off the connection from the hopper of each half-unit when the tubes are dropped down.

The flue connecting the treaters and the fans was made as cheaply as possible by using a wood frame with No. 25 gage black-steel sheets nailed on the inside of the frame. Strips of asbestos paper insulate (for heat) the steel from the wood frame. The space surrounding the fans was housed with a wood-frame corrugated-iron-covered building. This space is used for storing the potash dust while analyses are being made prior to shipment.

The electrode pipes were made of 16-gage steel and have loose flanges put on in the field, after which the pipe ends were hammered over the flanges. By bolting to the crown sheet, the tube and the sheets are brought into direct bearing. The electrode pipes, in addition to being held together by the upper and lower header plates, are fastened together in pairs by means of an iron plate bolted to T-bars that are riveted to the pipes, as shown. Swinging hammers hang so that, when swung by rods from a lever on the ground floor by the operator, they strike these iron plates and shake the precipitated dust loose from the interior of the pipes. Some of the flue dust, it is found, accumulates on the wire electrodes, although these are the positive electrodes. This is removed by occasional rapping. The hammer mechanism may be seen in Fig. 3: it consists of a cast-iron cylinder, chain-hung from a hand lever on the upper inspection platform. The connection between the lever and high-tension frame is made through a paraffined-maple stick insulator.

The central wire electrodes are suspended from a pipe frame above. This frame rests on Catalina marble insulating supports, as shown in Fig. 3. The wires have to closely approximate their central position at all times, and to this end they are guided by each passing through a sleeve in a light steel frame grid that rests on the weights attached to each wire. As shown in Fig. 3, this frame is allowed free vertical motion by being guided by a crossbar supported on Catalina marble slabs.

A novel scheme was employed to secure even distribution of gas through the electrode pipes; 2x2-in. angles

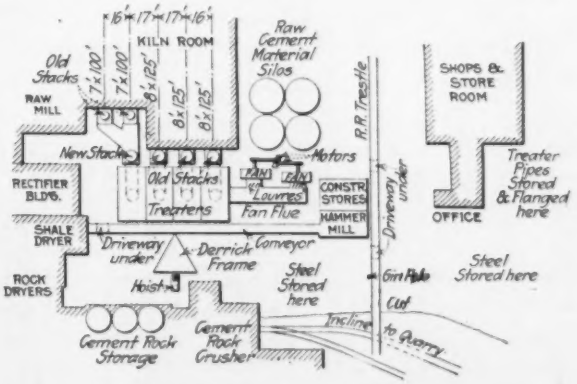



FIG. 2. GENERAL LAYOUT OF POTASH PLANT IN SECURITY MILL

were laid loose, corner up, across the 3x3-in. angle frame extending across the floor of the inlet chamber above the high-tension frame for the wire electrodes.

A reinforced-concrete structure, 33x40 ft. in plan and 20 ft. high, was built for housing the electrical machinery and is known as the rectifier building. Here are housed all the transformers, rectifiers and switching apparatus for the entire potash plant.

The electrical equipment consists of two 7.5-hp. 5-kw. motor-generator exciter sets; four 15-hp. 10-kv.-a. 220-volt single-phase 60-cycle 1,800-r.p.m. motor-generator sets, each directly connected to the shaft of a rotary rectifier; four 220- to 70,000-volt 60-cycle 10-kv.-a. transformers of special construction; and all necessary switchboards and accessories.

The scheme of operation in the rectifier building is as follows: The power supply is 440-volt three-phase 60-cycle current; this comes in through a meter on a distributing switchboard and is used to drive the exciters, motor-generator sets and fans. Each of the four units of the treater is supplied from its own individual motor-generator, transformer and rectifier. The motor is driven by the 440-volt current, and the coupled generator produces 220-volt 60-cycle single-phase current that goes to the transformer, where it is stepped up to 70,000 volts. From the transformer the 70,000-volt leads go direct to

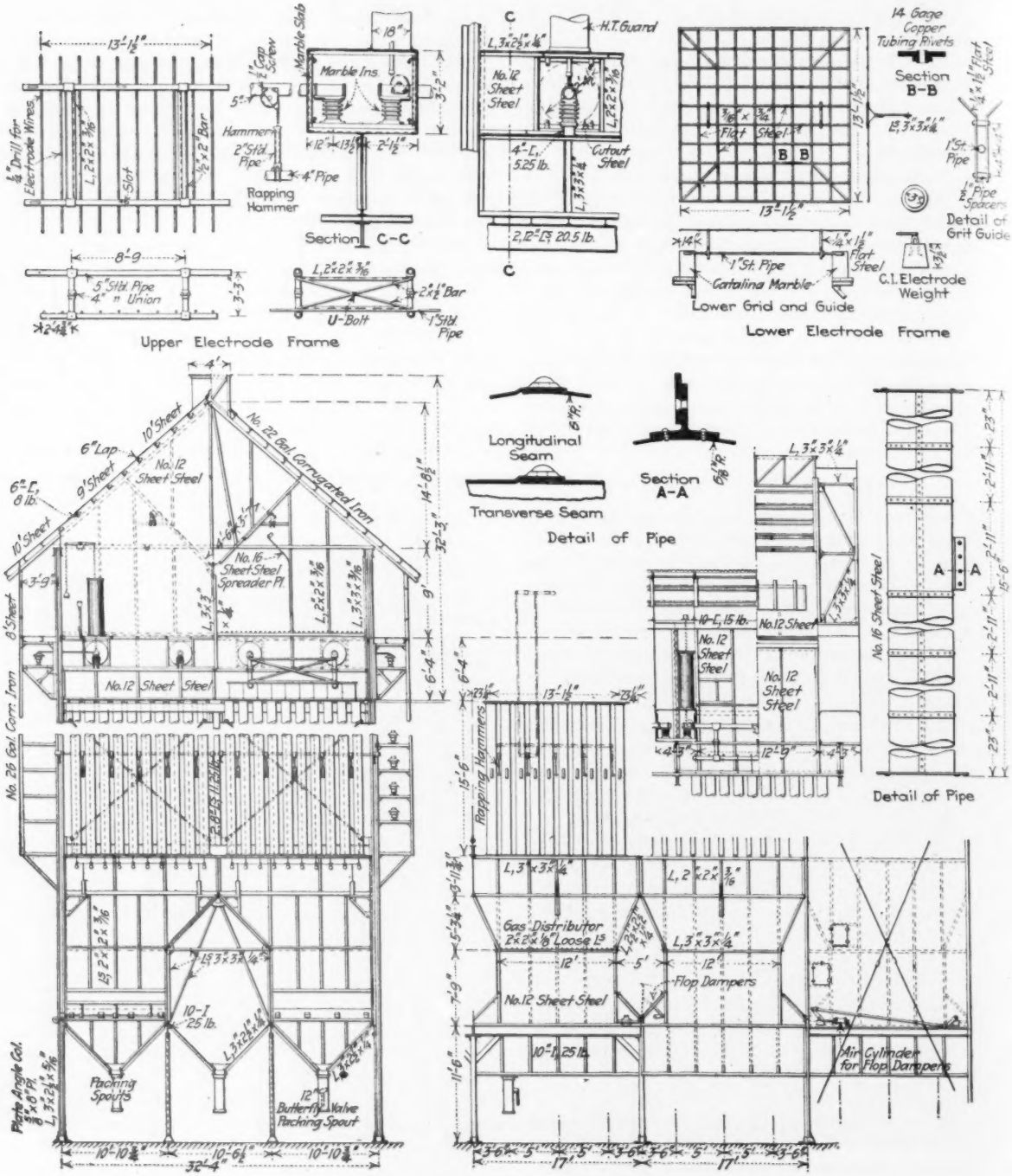



FIG. 3. DETAILS OF POTASH PLANT CONSTRUCTION
Security Cement and Lime Co., Hagerstown, Md.

the connection on the rectifier. The bottom connection to the rectifier is grounded (as is also all exposed metalwork in the building). From the top connection on the rectifier a wire goes toward the ceiling to a disconnecting switch. From this switch a line goes to the north end of the rectifier building, where are located high-tension switches so connected that it is possible to connect or disconnect either or both sides of any individual treater. All disconnecting switches are equipped with grounding clips, so that when the switches are open, the dead side is automatically grounded.

Throughout, on all the high-tension circuits 70,000-volt four-petticoat pin-type porcelain insulators are used. Inside the rectifier building 3/8-in. pipe is used for all high-tension lines.

From the distributing panel in the rectifier building a three-phase 440-volt circuit is taken to the north end of the treater building to operate the two fan motors. The fans were rated as taking 26 hp. each when operating at full rated load, and 35-hp. variable-speed (600 r.p.m. synchronous speed) motors were installed. Each fan is belted direct to its driving motor. The fan wheels are Sirocco,

10½ ft. in diameter by about 4 ft. wide. The fans each have a full-load rating of 100,000 cu.ft. per min. (temperature, 800° F.) at 125 r.p.m. when working against a suction of 0.5-in. water head. In addition to being able to control the speed of the fans, louver dampers were placed in the suction side of each fan. The fans have e-vase (expanding) chimneys to reduce the power consumption. The determination of fan capacity could not be made with accuracy because of unknown maximum temperature.

### Construction Difficulties

The contract between the Security and Western Precipitation companies was signed on Feb. 8, 1916. But prior to actual signing the engineers of the Western company had been engaged on the general design, and the writer had been scouting around steel-fabricating plants so that when the plans should be received they might immediately be submitted to shops best able to push the steelwork through at maximum speed. Best results appeared to be probable from Buffalo over Baltimore, Philadelphia, New York and Pittsburgh. Market conditions were extremely bad. The price of raw materials was jumping by leaps and bounds, and it was very hard to get any company to accept a contract to construct the plant in the time desired. It was found absolutely necessary to pay liberal premiums in order to get quick deliveries. Labor conditions also were very bad, and only three days following the signing of the contract for steelwork a strike took place in Buffalo. This, however, was handled admirably and did not seriously delay things.

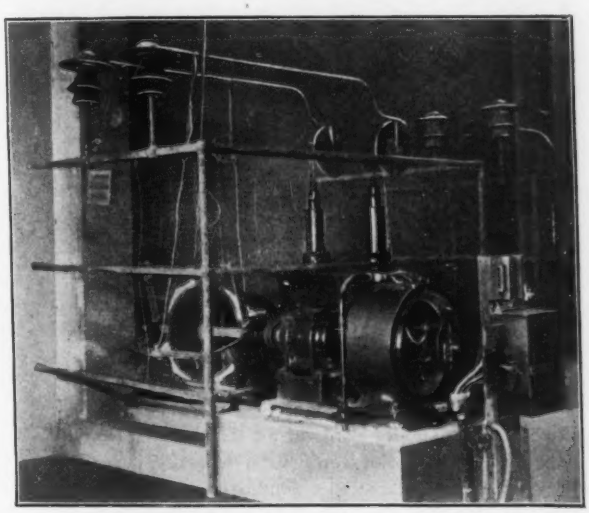


**FIG. 4. ONE OF THE MOTOR-GENERATOR TRANSFORMER-RECTIFIER SETS**

In operation; the four splashes of light around the rectifier disk are the high tension arcs where the 70,000-volt alternating current is broken in being made unidirectional

It was very difficult to get reasonable deliveries of the special-size 16-gage steel sheets for making the pipes; these had to be rolled specially and shipped from Youngstown to Brooklyn, N. Y., where the pipes were made up. The actual manufacture of these steel pipes (there were 800 of them, 1x15½ ft.) was one of the most difficult pieces of work encountered. They had to be true to diameter and length and be free from projections on the interior surface. It developed that establishments on the Pacific Coast were more fully equipped and more experienced in handling this class of work than were the plants in the East. However, a contract was made with the American Spiral Pipe Works, of New York City; the actual manufacturing of the pipes was sublet to a shop in Brooklyn operating under the firm name of Hindley & Pendleton.

The Security company undertook the construction of the potash plants under the following separate contracts: Excavation, concrete, fans, steelwork, steel pipes, castings, stacks and flues, erection of steel, stacks, dampers, flues, castings and electrode wires, transformers and electrical equipment. The Western Precipitation Co. furnished the design, but shop drawings for the steelwork were made by the Lackawanna Bridge Co., of Buffalo, which concern furnished the fabricated steel. Other details were designed by the Guarantee Construction Co., of New York City, which company erected the steelwork and the various other mechanisms and helped in the purchasing of materials. The electrical equipment was installed by the Spangler Electric Co., of Hagerstown. Excavation, concrete and brickwork were done by W. H. Angle, of Hagerstown. Steel stack and flues were furnished by the N. Y. Central Iron Works, Hagerstown. The entire work was carried on under the direct supervision of the writer.

### Erection Difficulties

The difficulties encountered during erection in the field were caused by very limited space both for storing material and erecting. Also, considerable trouble was had with labor because of the dust from the cement plant. On windy days it was very disagreeable, to say the least, for the workmen to stay at their work. Almost ideal weather was encountered, and only a very few days were lost on account of rain.

After one unit was completed and placed in operation, the steelworkers let it be known that they would not work on the other units of the building while 70,000-volt current was being transmitted along its side. However, there were only a few of the men who left the job because of their fear of danger with the current on. In order to protect the workmen from the high-voltage wires, small-mesh wire netting was used for guards surrounding them. Danger signs were placed at every point along the building where there was any possibility of a workman's coming in contact with the wires. The men were all warned personally of this danger and told to keep as far away from the circuits as possible.

From the general layout of the cement mill and potash plant, Fig. 2, it will be observed that a derrick frame and hoisting engine were placed close to the middle of the dust treaters and on the east side. This was a stiff-leg derrick with a 60-ft. boom, and it was placed on a platform 30 ft. above the ground. By means of this it was possible to lift into place almost all the steelwork. It developed before placing the flues on top of the building that the boom of the derrick could not be used for setting them in permanent position, because the derrick frame was too close to the building and, therefore, could not reach over far enough. The cost of erecting the derrick was considerable, but it more than paid for itself. The space available for storage of steel was very small, but proved to be large enough as erection took place about as fast as the material was received.

Before erection was completed, the speed at which the men were worked began to tell upon them; and consid-

FIG. 5. BENEATH DUST-TREATER BUILDING
Showing method of bagging dust coming through spouts from hoppers

erable trouble was experienced in keeping them at work continuously. The erection crew worked from 10 to 12 hr. a day and 7 days per week, except as the weather interfered. A night crew was used part of the time. Efforts were concentrated upon one unit of the treater, so that operation might be begun at the earliest possible moment in order that the experimental stage, which comes inevitably with any new enterprise, could be covered with one unit while the others were being completed.

### Potash-Plant Operation

The views of the plant in Fig. 1 show the relative appearance of the gases discharged with current on and off. The operation of the plant has been profitable from the beginning, but experiments are still being carried on to determine the exact conditions under which the maximum amount of potash can be produced simultaneously with the maximum production of cement clinker. These experiments have opened up an unlimited field of investigation, which gives every promise of being the means of increasing the production and quality of the cement entirely aside from the production of potash.

At the present time, with two kilns 7x100 ft. and three kilns 8x125 ft., the production of potash dust averages from 20 to 25 tons per 24 hr., containing from 5 to 10% pure $K_2O$, which is present in the form of potassium sulphate ($K_2SO_4$) and is equivalent to approximately 10 to 20% of the sulphate. The dust is in a very finely divided state, which is highly desirable for use as a fertilizer. It collects in the lower hoppers of the steel treater structure and is drawn off regularly into burlap bags (see Fig. 5) containing some 100 lb. net. The bags are weighed and sampled before shipment.

The gas volume handled averages approximately 180,000 cu.ft. per min. and 900° F., when measured at the base of the kiln stacks. These figures may be compared with the 100,000 cu.ft. and 800° estimated in advance. A single fan, however, has no difficulty in maintaining draft under this load.

The operating labor required for the plant is a very small item, as one man during the day and one at night are all that are required to care for the treaters and electrical apparatus. A third man acts as general foreman both for the operation of the treaters and packing the material. The labor for doing the bagging is additional. The power consumption for the entire plant averages about 1,000 kw.-hr. per 24-hr. run, and this includes power for precipitation, fans and a small compressor that supplies air for operating dampers, etc.

Some of the factors affecting the successful operation of the plant are: Regularity of shaking down the dust, temperature of gases, fuel analysis and fuel economy for the kiln, rate of flame propagation in the fuel-air mixture, volume and velocity of gases treated, and gas distribution in the electrode pipes.

It has been found that if the dust was not shaken down from both electrodes at regular intervals, but allowed to collect on the wire electrodes, it resulted in burning off the wires and causing short-circuits. Also under certain conditions the dust would form in lumps at nodes on the wires and cause flash-over at those points. This was a very serious difficulty during the early stages of operation; but after the cause was discovered and steps taken to rectify it, no further difficulty was experienced.

The temperature of the gases has been one of the hardest things to control, as the operators of the kilns were not accustomed to watching the kiln pyrometers, which had just been installed. Of late this has been partly overcome, and temperatures have been greatly decreased. This was brought about by reducing the amount of coal fired into the kilns and by controlling the draft at the proper places so as to get the combustion to take place inside of the kiln and not have some unburned fuel carried over into the treaters. It was found that certain kinds of coal burned at a much slower rate than others, and with the slow-burning coal considerable difficulty was had with high treater temperatures. The volume and velocity of gases treated can be controlled to a certain extent. However, this must be watched closely in connection with production of properly burned cement. The proper distribution of gases in the electrode pipes has been brought about by properly balancing draft pressures in the treater by means of distributors made of pieces of upturned angle iron, already noted.

### Cement Production Improved

The effects on the production of cement are very noticeable. The operation of the potash plant has been the means indirectly of increasing the production of cement clinker and also the fuel economy. It has been the means of getting more continuous operation of the kilns because of requiring much better attendance on the part of the kiln operators. This automatically brings about a better quality of cement clinker because, by watching the kilns more closely, the quality of the clinker will be more nearly constant. Moreover, it is found that the best recovery of potash is secured coincident with the best burned clinker.

# Binghamton Builds Interceptor with Four River Crossings

By A. L. LaRoche*

The City of Binghamton, N. Y., is building a 4½-mi. 12- to 54-in. intercepting sewer with four river crossings. This is being done to prevent the highly polluted summer condition of the Susquehanna and Chenango Rivers, which join in Binghamton. During dry summer seasons both streams drop to a very low point, and the velocities decrease accordingly. The sewage of the city empties into these rivers through nine separate trunk-sewer systems, and therefore a highly polluted condition has existed in the streams during that part of the year when it would be most objectionable. The work now under construction is intended to prevent pollution of the rivers only when they are in a fairly clean condition. During spring freshets or excessive general storms the rivers already carry a heavy amount of foreign material, which would not be appreciably increased by the addition of the city's sewage.

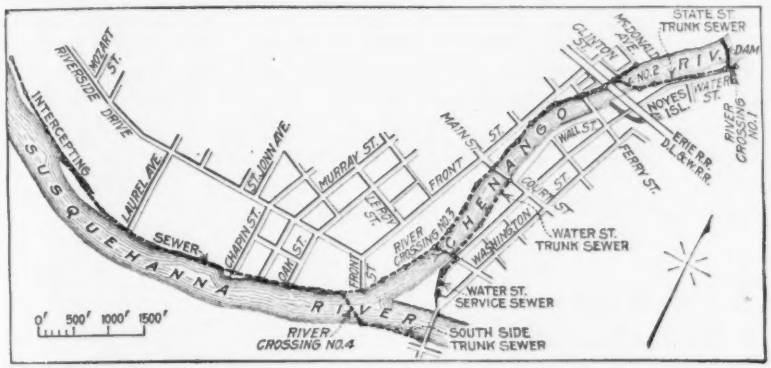



FIG. 1. MAP OF BINGHAMTON INTERCEPTING SEWER

The complete plan contemplates the construction of an intercepting sewer picking up the flow of trunk sewers at or near the outfalls and carrying this sewage to a disposal plant for treatment. The existing sewer system is chiefly of the combined type, and figures for the design of the interceptor were based upon an adjustment between the dry-weather flow and that portion of the storm water which on the average came when the rivers were lowest.

Stream gagings taken for a number of years were used in determining this relation. The dry-weather flow figures were obtained by gagings on each trunk sewer, but the gages used were of a type that gave only the maximum dry-weather flow for each day. Actual water consumption in each sewer district was therefore also obtained. A comparison and adjustment of these quantities gave a resultant daily-flow curve assumed to be close to the present actual conditions. Each district was then considered from a viewpoint of future development, and figures were prepared showing the estimated flow in 1940. The estimated future flow was increased by 30% to care for the surface water that would come before the streams would rise and so prevent a pollution from the first runoff. The design of the interceptor was based upon these figures with a limiting minimum velocity of 2½ ft. per sec. The work of constructing this sewer is divided into two sections. Section 1 picks up all the outfalls in the city and has a length of approximately 2 mi.; Section 2 runs from the end of Section 1 to the proposed site of the disposal plant, a distance of approximately 2½ mi. The route of this sewer closely follows the shore line of both rivers, in some places being entirely within the dry-weather bed of the streams. The soil encountered is a mixture of river silt underlain by a layer of gravel with occasional showings of shale rock above the invert elevation.

The construction of Section 1 is now under way. The pipe being used for sizes from 12 to 24 in. inclusive is vitrified tile, in 3-ft. lengths, double strength where available. The 36-, 42- and 48-in. sewer is of reinforced-concrete pipe, cast in 4-ft. lengths at three plants distributed along the route, and delivered by the pipe manufacturers close to the line of the work.

Vitrified pipe is laid with bituminous joints except where a surrounding concrete protection is placed. At these points cement-grout joints are being used. In laying this pipe the trench is unwatered to within 6 in. of

*Deputy Engineer, Binghamton, N. Y.

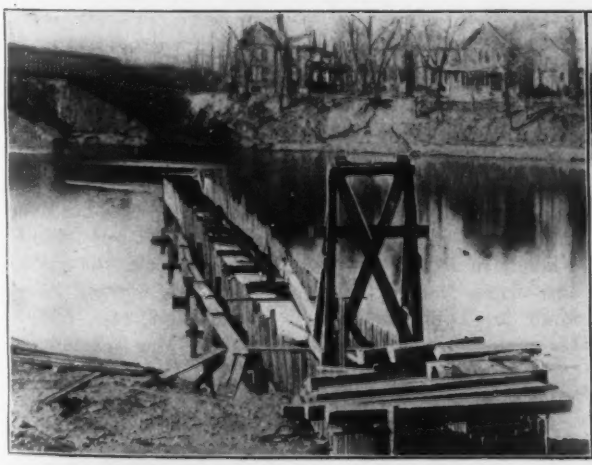


FIG. 2. COFFER-DAM FOR CROSSING 2, BINGHAMTON INTERCEPTOR

FIG. 3. SECOND COFFER-DAM AND CONTRACTOR'S PLANT FOR CROSSING 3

the invert. A recent test of 250 ft. of the bituminous-joint construction on 24-in. pipe showed one small leak.

The method of protecting the vitrified-pipe sewer where its elevation brings it above the original surface is by driving steel sheetpiling on each side 6 in. from the pipe. The piling has an average penetration of 5 ft. and is driven by hand. After the pipe is laid and an earth-fill tamped into place between the lines of piling, a 6-in. concrete slab is cast over the top. Where the pipe is not above the surface of the ground, but is so close thereto as to be in danger from the scouring action of the heavy floods, it is completely embedded in concrete extending 9 in. beyond the pipe on each side and running down 12 in. below the invert with a thickness on top of 9 in.

### Laying Concrete Pipe

Concrete pipe is laid with grout joints, the trench being entirely unwatered. During construction it has been necessary, on account of the excessive amount of water encountered in a gravel stratum near the invert, to use underdrains at certain places along the line. This consists of an 8-in. tile pipe, laid with burlap joints, placed along one side of the trench below the elevation of the bottom of the pipe. The pumping equipment on the 48-in. sewer is one 8-in. centrifugal working against a head of approximately 20 ft. This is placed in a sump at the lower end of the 48-in. section and unwaters the trench down to the invert. A 4-in. diaphragm pump, placed in the trench where pipe is being laid, discharges over a bulkhead into the sewer already laid and keeps the trench dry for pipe laying.

Where the interceptor meets with branch sewers situated on the same side of the river, regulating chambers will be constructed. These consist of a grit chamber on the trunk sewer, the outlet of which chamber empties directly into the interceptor. A bypass from the grit chamber cares for the excess surface flow beyond the capacity of the interceptor. This bypass is checked against a rise in the river by a check valve. When the river is at abnormal height, the interceptor will therefore be flowing full; and a sufficient head will be built up in the trunk sewer to force a flow through the check valve. The backing up in the sewer system will not, however, be greater than that experienced in the past.

Where outfalls are on the opposite shores of the rivers, inverted-siphon river crossings are being constructed. These are equipped with grit and regulating chambers at the inlet end similar to those mentioned above. The largest of these crossings (No. 3 shown in detail in Fig. 5) carries a present flow of approximately 4,800,000 gal. per day, and the estimated future flow is 12,200,000 gal. From the grit chamber the flow passes into the inlet siphon chamber. From here three 18-in. cast-iron pipes embedded in concrete carry the sewage under the bed of the river. Two of these pipes have the same inlet elevation, while the third pipe is raised at its inlet a height of 18 in. This arrangement permits the closing and cleaning of any pipe in the crossing, since a single lower pipe will care for the present flow, and the two lower pipes or one lower and the upper pipe will care for the future flow. All three pipes are equipped with sluice gates at both inlet and outlet ends.

Directly in back of the inlet chamber is the cleaning well, which is carried down below the bottom of the lowest part of the siphon. Into this cleaning well 18-in. return pipes are carried from T's placed in the main

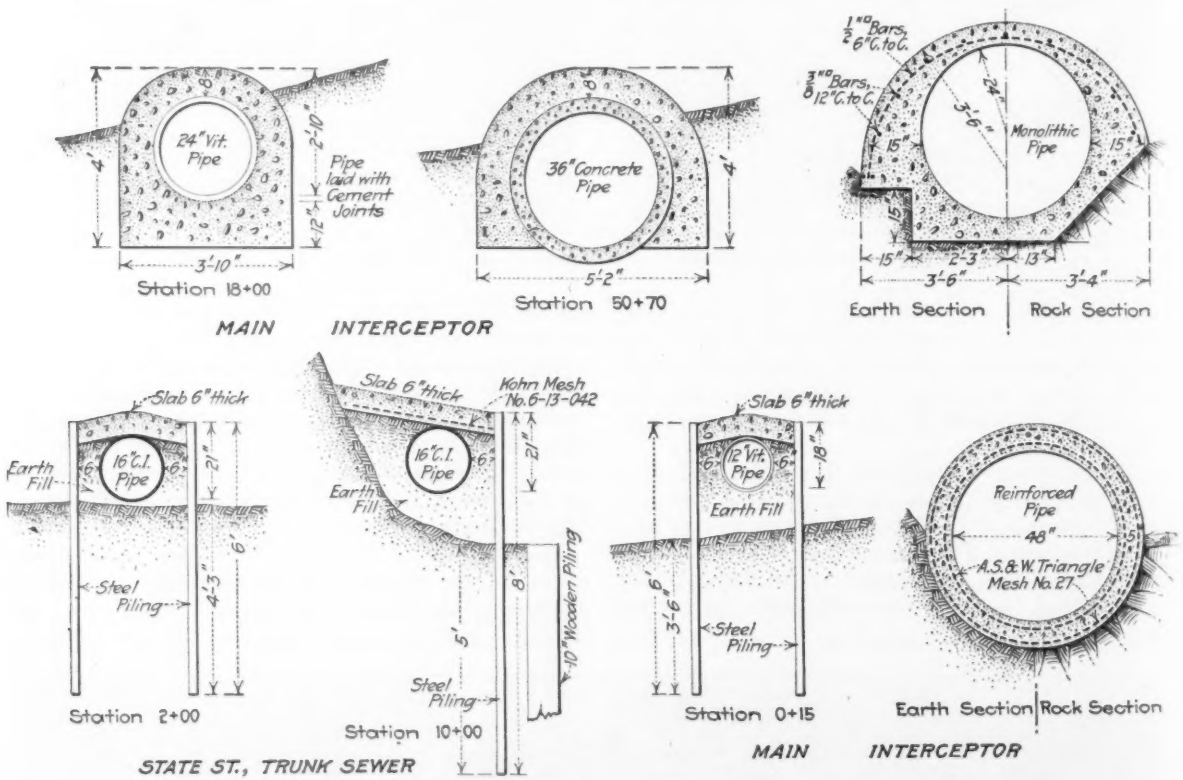



FIG. 4. TYPICAL SECTIONS, SHOWING BINGHAMTON INTERCEPTOR CONSTRUCTION

crossing pipes. Similar pipes and T's are placed also at the outlet end of the siphon, where a second cleaning well is constructed. The ends of the cleaning pipes are equipped with flap valves held tight by capscrews, and to these valves are attached standard fire-hose connections. From cleaning well to cleaning well there is a straight run in each crossing pipe. This arrangement permits both flushing and rodding the entire length of the siphon. At the outlet end all three pipes discharge at the same elevation, where they have a free fall into the interceptor.

### Construction Work at Crossing 3

Construction of crossing No. 3 started with the excavation of the inlet chamber and the driving of a steel sheet-piling coffer-dam approximately one-fourth of the distance across the stream. The first coffer-dam was 86 ft. long and 9 ft. wide, and the lines for driving the sheeting and for maintaining a proper width were given by floating 8x 10-in. timber frames into place, straddling the center line. These frames were in sections about 10 ft. long and permitted easy access for laying pipe without disturbing the crosspieces. The coffer-dam was unwatered by a 6-in. centrifugal pump and was kept dry by two 2-in. steam ejectors and one 4-in. gasoline-engine diaphragm pump. The average head of water on the outside was 4 ft., although at one time this was increased to 7 ft. by a sudden rise in the river. The ditch for these cast-iron pipes was excavated by hand in hard gravel, this material being removed by a clam-shell bucket.

The contractor's plant for driving coffer-dam and handling excavated material was carried on a wooden barge of sufficient size with its maximum loading to draw not more than 15 in. of water. The plant consists of a 9-ton hoist boiler, derrick and boom to carry the steam hammer or clam-shell bucket. At the derrick end of the barge, sliding spuds are let down to the river bottom and locked in position to insure stability and to hold the barge above water when the boom is loaded. The steam for driving the hammer was furnished from a boiler erected on the shore.

The shore end of this coffer-dam kept the inlet chamber dry, and concrete for this chamber was placed while the iron pipes were being laid. When the pipe laying here was complete, this first coffer-dam was pulled and a second one driven farther out in the stream and inclosing the ends of the pipe lines. It is intended to unwater this second coffer-dam by a pump placed at the shore end of the crossing pipes and by using these pipes as drains. This shore pump will be augmented by a second pump placed on top of the coffer-dam.

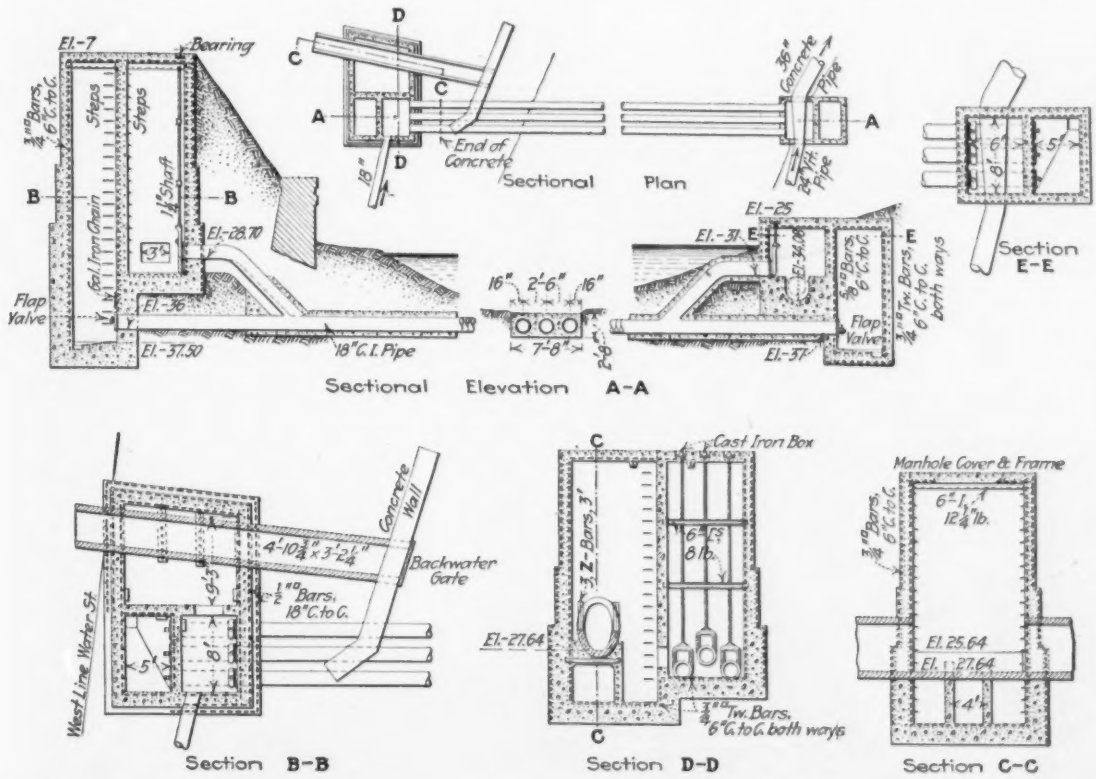



FIG. 5. DETAILS OF RIVER CROSSING NO. 3, BINGHAMTON INTERCEPTING SEWER

Excavation for the 48-in. concrete sewer is being done by No. 3 Keystone excavator. The maximum cut encountered is 14 ft.; and the machine is doing the entire excavating except for the bottom trimming, which is in soft shale rock and is taken out by hand. It is also used for backfilling by reversing the direction of the digging apparatus.

The Sewage Disposal and Water Plant Co., of Schenectady, is the contractor for Section 1. It is intended to continue with the construction of Section 2 of the interceptor and the disposal plant in 1917.

# New Type of Concrete Floor on St. Louis Bridge

*SYNOPSIS—Steel formwork introduced as simpler and cheaper than wood, and steel reinforcement made up in mats and unit sets of bars to facilitate placing. Concrete distributed by revolving dump-cars.*

Construction methods and difficulties are not always apparent in the design of structures, and this fact is illustrated by some interesting features in the floor of the roadway portion of the east (Illinois) approach viaduct of the new municipal bridge over the Mississippi River at St. Louis, Mo. The wood paving is carried by a concrete slab resting on longitudinal steel girders and joists that are spaced 4.50 and 4.92 ft. apart and are framed between the transverse girders. The concrete is extended downward to inclose and protect the steel framing. Fig. 1 shows the steel formwork and reinforcement being placed.

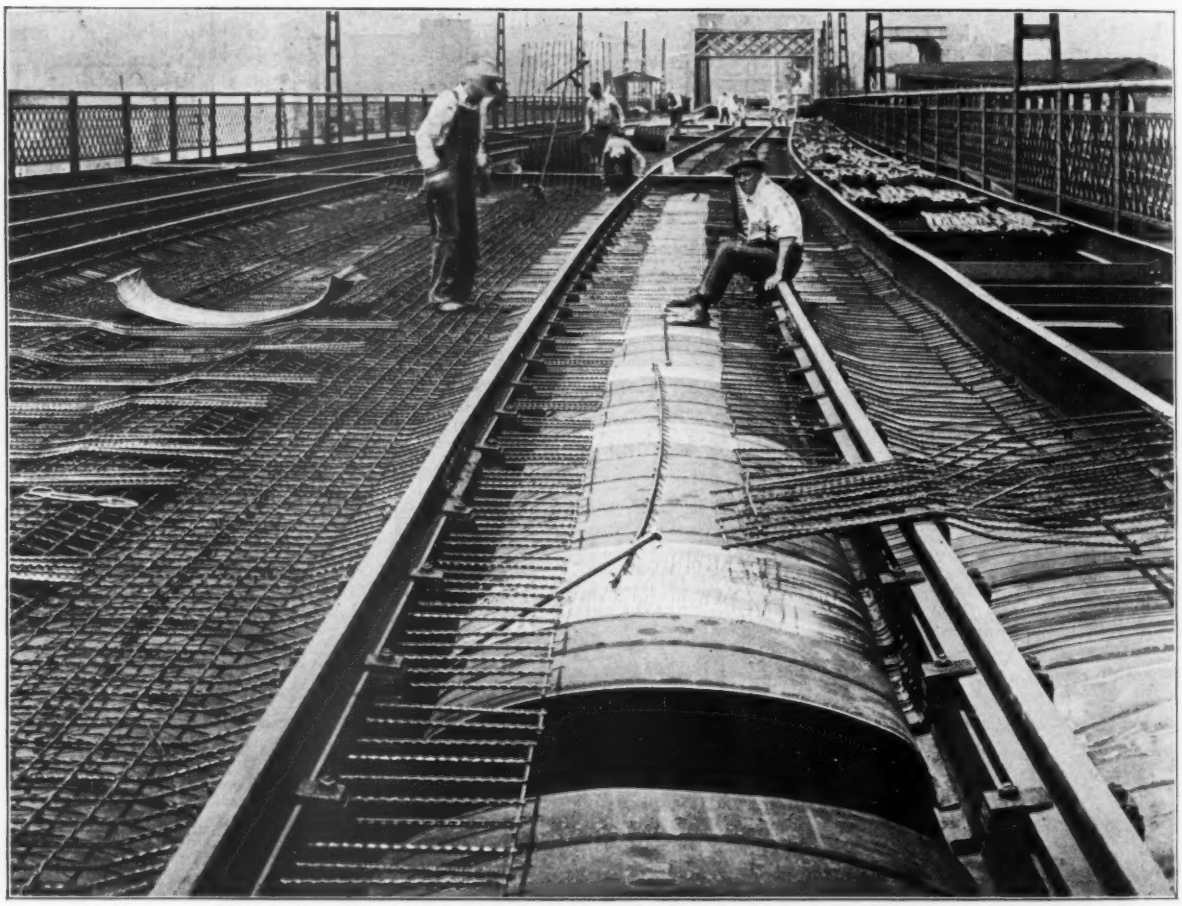


FIG. 1. STEEL FORMS AND REINFORCEMENT FOR THE CONCRETE FLOOR OF THE ILLINOIS APPROACH TO THE MUNICIPAL BRIDGE OVER THE MISSISSIPPI RIVER AT ST. LOUIS

The original design, shown at the left in Fig. 2, consisted of a flat slab with tapering ribs along the joists. The building and removal of wood forms for this flat slab and trough construction would have been costly and slow, especially as the removal would have had to be done from staging or falsework beneath the deck, at a considerable height above the ground.

To simplify the work and reduce the cost, a modified design was therefore prepared by the city's engineers in charge of the construction (which is being done by municipal forces). This consists in arching or curving the lower side of each section of the slab and supporting the concrete on a form of arched plates of thin sheet steel (No. 22 gage), which are fitted between the joists and rest upon their flanges (or upon shelf angles of the outside longitudinal girders). This formwork is left in place and will gradually rust away, having served its purpose as soon as the concrete has set. This modified construction is shown at the right in Fig. 2. The arch is of 48⅛-in. radius in the main portion and 8$\frac{11}{16}$ in. at the sides.

The steel sheets are pressed to shape. Each is about 22 in. long, with a ¾-in. corrugation at each end and in the middle to stiffen it and hold the shape. The end corrugations interlock, as the plates lap each other. For the sidewalks the width (6 ft.) is too great for arching the slab, and the steel sheets are pressed to channel shape, as shown. They are flat on top for about 5 ft., and the

sides slope outward to rest on the lower flanges of the sidewalk stringers. These wide form plates are stiffened by angles pressed to the same shape and welded to the under side. The steel forms were made by the Hydraulic Pressed Steel Co., of Cleveland, Ohio.

The steel reinforcement of the concrete floor slab consists of transverse bars and layers of heavy wire netting of special make. The original design provided for longitudinal rods, but with the great number of rods and the cost of labor, the placing of these would have been very slow and expensive. Instead, a special make of wire netting was used, the longitudinal strands of which were equivalent to the rod sections. No allowance is made for the diagonal wires as reinforcement.

To reduce the difficulty and cost of handling and placing the very large number of transverse rods, these are made up into sets of seven bars each, held together at the ends by light bars welded to the under side. They are held also at two intermediate points by spacers, which are flat strips of metal having lugs stamped out to be bent over the bars. These mats are 16 ft. 5 in. long and about 4 ft. wide, and each can be handled readily by two men. Similar mats 6 ft. long are used for the sidewalk slab.

The car-track rails formed an obstruction to the placing of the mats, as they are supported above their I-beams by chairs staggered in position (33 in. apart). For each side of the roadway there is a mat extending from the curb to the track, with its bars extending beneath the outer rail. A third and narrower mat is placed between the tracks, with its bars extending beneath the inner rail of each track. Loose bars are placed between the rails of each track and are wired to the projecting ends of the bars of the mats on either side (inside the rails). This wiring is done mechanically by the use of prepared wire loops that secured by bolted clips. These supports are 33 in. apart and are staggered in position, as noted above.

For concreting this roadway floor on the viaduct approach, two mixer plants were used, one at each end of the approach. The one at the higher or bridge end had elevated material bins in the usual way, while for the one near the lower end the materials were placed in stock piles and wheeled to the mixer. An 80-ft. steel elevator tower

FIG. 3. PLACING CONCRETE WITH SMALL REVOLVING DUMP-CARS ON STANDARD-GAGE TRACKS

was used, high enough above the bridge deck to supply an inclined chute extending across the deck. For distributing the concrete the standard-gage car tracks were utilized, as shown in Fig. 3.

For each track there was a train of two or three cars operated by a Whitcomb 6-ton gasoline locomotive. The cars were of an improvised type, as standard-gage equipment of the small capacity desired was not to be had.

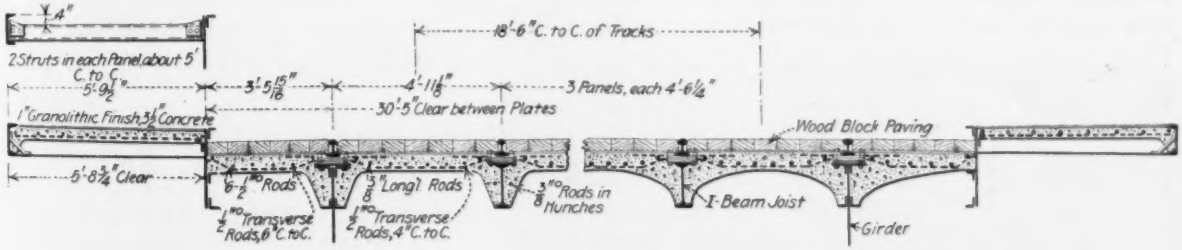

18'-6" C. to C. of Tracks
2 Struts in each Panel about 5' C. to C.
3 Panels, each 4'-6¼"
30'-5" Clear between Plates
1" Granolithic Finish, 3½" Concrete
Wood Block Paving
5'-8¾" Clear
½" ø Rods
⅝" Long Rods
⅜" ø Rods in Hunches
½" ø Transverse Rods, 6" C. to C.
½" ø Transverse Rods, 4" C. to C.
I-Beam Joist
Girder
Part Section of Slab as Designed
Part Section of Slab as made with Steel Forms

FIG. 2. CROSS-SECTION OF ROADWAY, SHOWING ORIGINAL AND MODIFIED DESIGN OF CONCRETE SLAB

are set in place and then twisted by a hand tool with a revolving stem. This device is made by the Curry Manufacturing Co., of New York City.

Fig. 1 shows the whole construction very clearly. In the center is one of the tracks with the arched form sheets in place. On each side of this is a panel with the form sheets and the welded sets of transverse rods, the ends of these rods projecting under the rails into the track space. In the panel at the left of the track the woven-wire mat is also in place, laid upon the transverse bars. Some of the form plates and the welded sets of bars are shown lying around, while in the middle of the track space is one on the spacing bars. At the right is the sidewalk framing (with no form plates in place).

The street-car tracks have 90-lb. T-rails (Am. Soc. C. E. section) supported on chairs with insulating strips and

Each concrete car is a railway push-car having mounted on it a 1-yd. steel dumping body or hopper. The body is carried by a revolving base, so that it can dump on either side or endwise between the rails. At first the trains were all loaded on the track nearest the elevator tower, but this involved an inconvenient amount of switching and interfered with the free movement of the trains. The temporary crossover was taken out, therefore, and the chute was extended across the roadway to serve both tracks, so that each train could be operated independently on its own track. In Fig. 3 one car is dumping at the side, while the other has the body in position for end dumping

The work is being done by day labor under the direction of the Board of Public Service, of St. Louis, Mo. It is in charge of Clinton H. Fisk, Chief Engineer of Construction, and W. F. Collar, Superintendent of Construction.

# Notes from Field and Office

**Field methods for surveying subsurface structures in Milwaukee—Bridge piers in Carolina flood district broke at pouring joints—How a long-standing boundary dispute was settled; an excellent example of retracing survey methods**

## Surveying for the Milwaukee Intercepting Sewers

By Darwin W. Townsend*

For the purpose of obtaining information relative to the existing underground and surface structures over the routes of the proposed intercepting sewers in Milwaukee, Wis., three field parties were organized early in March, 1915. Each party consisted of a chief, a transitman and two rodmen. Preparations were made at the same time, by increasing the drafting-room force, to keep the notes plotted up to date, as they were received from the field-party chiefs at the end of each day.

Loose-leaf notebooks, with pages 7⅞x5 in. (see Fig. 2) were used in the field, and three pages were given to each city block. Page 1 showed property lines, curb lines, block distances and street widths, together with the location of all manholes, fire wells, etc., visible from the street surface. Page 1-a gave level notes of the elevations, top and bottom, of manholes, etc., and page 1-b showed cross-section sketches of all manholes investigated.

The first page for each city block had the property and curb lines sketched upon it before the page was handed over to the field-party chief. The curb and property lines from which the sketches were made were taken from the official quarter-section maps of the city, and one man was occupied in the drafting room the greater part of his time in the preparation of these notebook pages. The time spent upon the sketches proved its worth, however, time and again, as it always served as a check for tying in manholes between the intersecting streets.

Each field party operated as follows: All manholes in a block were first tied in to the curb lines; next, they were opened up and investigated, and a sketch was made. Last the elevations were taken upon the rims at the street surface. These notes were plotted to a horizontal scale of 40 ft. = 1 in., and a vertical scale of 6 ft. = 1 in. As soon as the notes were "cold," they were filed away in envelopes and indexed under their proper headings.

All records pertaining to gas mains were secured from the Milwaukee Gas Light Co., and the locations and sizes were transferred directly from their plans to ours.

By Aug. 1, 1915, all the routes, a total of 32 mi., were surveyed and plotted. While the major portion of the sewer routes were in city streets, as before mentioned, several miles were in practically undeveloped territory, necessitating topographic and location work. Soundings for proposed pressure siphons were also taken across the Milwaukee, Menominee and Kinnickinnic Rivers at 13 different places.

Fig. 1 shows a typical street intersection upon which is plotted all available information concerning the under-

*Chief Draftsman, Sewerage Commission, Milwaukee, Wis.

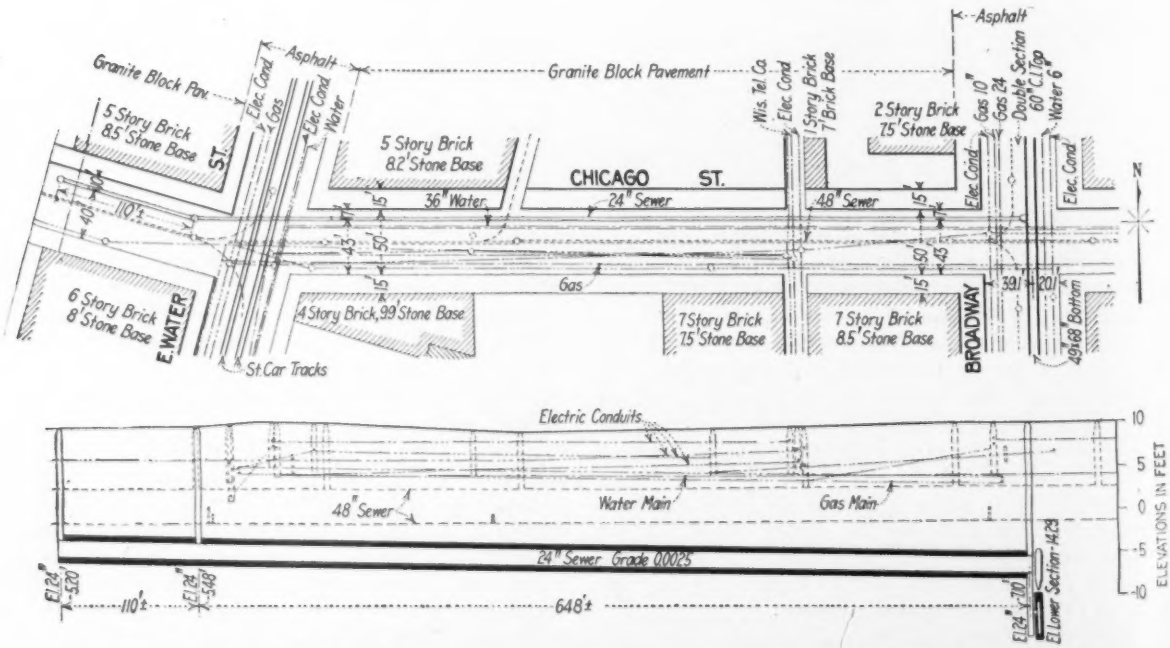
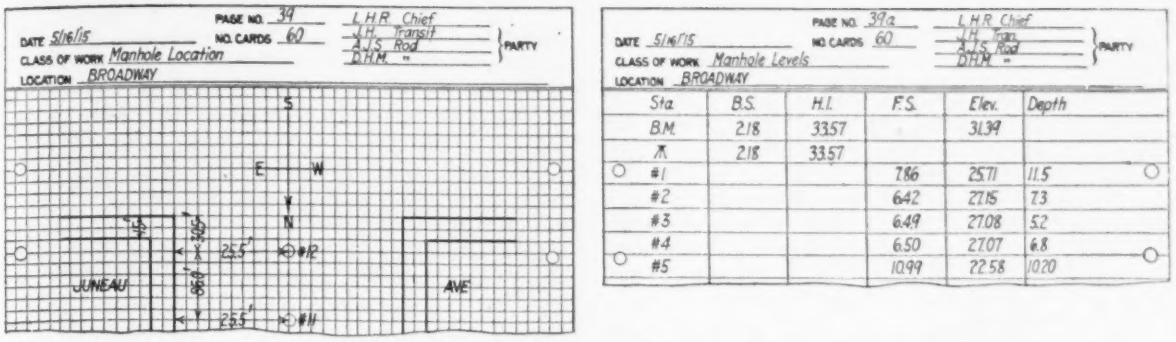



FIG. 1. TYPICAL STREET INTERSECTION, SHOWING ALL DATA OBTAINABLE




| Sta. | B.S. | H.I. | F.S. | Elev. | Depth |
|---|---|---|---|---|---|
| B.M. | 2.18 | 33.57 | | 31.39 | |
| ⏃ | 2.18 | 33.57 | | | |
| #1 | | | 7.86 | 25.71 | 11.5 |
| #2 | | | 6.42 | 27.15 | 7.3 |
| #3 | | | 6.49 | 27.08 | 5.2 |
| #4 | | | 6.50 | 27.07 | 6.8 |
| #5 | | | 10.99 | 22.58 | 10.20 |

FIG. 2. TWO SIDES OF LOOSE-LEAF FIELD NOTES: MILWAUKEE SEWER SURVEYS

ground structures; but, as usual, structures of which no records were obtainable were encountered when the trenches were opened up for the construction of the intercepting sewers.

In locating the lines for the proposed sewers in the streets the path of least resistance was naturally adhered to in practically all cases, exceptions being made of course where this would involve needless expenditure, and a short-cut was deemed advisable to save grade.

Accurate time records were kept both in the field and the drafting room during the five months this work was in progress. The cost per mile for fieldwork was $42, and for drafting-room work $90, both exclusive of material and administration costs. The seemingly high cost of drafting-room work is due to the fact that not only were the field notes plotted, but practically all the designs for sewer and tunnel cross-sections, standard and special manholes, shafts, junction chambers, etc., were completed during these five months. This, of course, necessitated carrying sufficient drafting-room force for that purpose. No tracings were made, however, during this time.

The work was done under the supervision of the Milwaukee Sewerage Commission, of which T. Chalkley Hatton is chief engineer.

## Contractor Discusses Bridges Damaged by Flood

A prominent contractor, during a recent trip through the flood district of the Catawba and the French Broad River Valleys of North Carolina, studied the effect of the high water of July last on concrete-bridge foundations. From his observations he deduces some interesting conclusions regarding the stability of such structures.

The July, 1916, rainfall on the watersheds of these rivers was the heaviest recorded in the United States. At Altapass, N. C., the 24-hr. rainfall, July 14-15, is reported as 22 in. Altapass is the dividing line of the watershed of the Catawba River and the headwaters of the tributaries of the Tennessee River. The Catawba flows to the Atlantic Ocean, and the Tennessee River to the Gulf of Mexico through the Ohio and Mississippi Rivers. The Catawba is reported to have risen 48 ft. in 8 hr., the stage being 18 ft. higher than any previous record.

At Mt. Holly, N. C., the Catawba was spanned by three bridges in the following order—county highway, Seaboard Air Line Ry. and the Piedmont & Northern Ry. (electric line). These are only a few hundred feet apart. The county bridge was not a very heavy structure. The Seaboard bridge was a deck truss on stone piers and abutments, and the Piedmont Northern was a deck truss on concrete piers and abutments, built in 1911 and of heavy construction. As described by an onlooker, the Piedmont bridge was weighted down by 10 carloads of coal in an effort to hold it. The drift piled against the Seaboard bridge until this bridge finally gave way, the wreckage sweeping down against the Piedmont bridge, which was wrecked. The steelwork and cars were carried downstream from one to several hundred feet, while one 60-ft. girder span was carried into an adjacent field about 1,000 ft. from the bridge site.

Of the Seaboard bridge one of the stone abutments remained standing, but the piers were gone. The abutments of the Piedmont bridge remained intact; the flood washed out the dirt fill behind the abutments which, being built without wings, appear at a distance like piers. The first span from the abutment on the Mt. Holly side to Pier No. 1 is of 60-ft. girders. Between Piers 1 and 2 is the first deck-truss span. When the bridge went out, Pier 2 broke off a few feet above the foundation concrete, and at a point where the pouring had stopped at some time during the construction of the pier. In falling, the pier broke again; and again the failure occurred where the pouring had stopped for a time. The two channel piers, with their foundations, turned over and broke in blocks right where the several pourings had stopped. The pier on the Charlotte side is intact, although about 12 ft. of coping on the pier went with the span, which was bolted to the coping (18x5 ft. by 18 in. thick). The bolt took the upstream portion of the coping, leaving about 6 ft. of the downstream coping on the pier.

The piers all seem to be broken where the pouring stopped for the day. The bonding stones of one-man size pulled out of the concrete. Except for these breaks the piers are undamaged; and if it were possible to handle the pieces, they could probably be fitted one on top of the other, just as they were before the flood.

This is very good evidence that there is little bond between successive pourings of concrete. It is questionable whether it would not be better not to bolt steelwork to concrete piers. The piers to which the trusses were bolted failed, while the abutments on which the steelwork rested unbolted remained standing.

Farther up the Catawba River there were a few highway bridges carried on steel cylinders filled with concrete, but they did not last long. At one point the concrete pier and abutments of a highway bridge stand, but there is no trace of the steelwork, the flood evidently having topped the concrete some 10 or 12 ft. At one point on

the Southern Ry. a wing of a 12-ft. arch (approximately) broke on the downstream side and washed downstream about 40 ft.

On one of the tributaries of the Catawba, near Old Fort, N. C., a few concrete abutments for highway bridges with earth approaches and steel superstructures were washed away, but the concrete was not damaged. A concrete bridge at Biltmore across the Swannannoa River, completed a short time before the flood, was uninjured.

At Asheville, N. C., the Southern Ry. crosses the French Broad River on heavy reinforced-concrete piers about 25 ft. high and 30 ft. apart. Millions of feet of lumber piled against this bridge, which for several hours acted as a dam, but it was not carried out. Below Asheville were a couple of highway bridges finished a short time before the flood. They were carried on 36-in. round concrete piers tied together by a 12-in. concrete web. The steelwork of the bridges was washed down the river, while these piers, poured monolithic, stand intact, except where a pier broke loose from its anchorage in the granite river bottom. The broken piers look as if they might be put back in place and be as good as before.

Considerable damage was done to railway embankments, and the Southern Ry. is now building rubble-masonry walls for future flood protection.

## Retracing An Old Survey To Settle Boundary Dispute

After more than a century of controversy the boundary line between the states of Ohio and Michigan has been defined to the satisfaction of both parties; and of all state boundary controversies, of which there have been many, there is probably none that has a more interesting history than this.

### Historical Summary

The whole trouble grew out of a misconception of the geography of the Northwest Territory at the time the famous Ordinance of 1787 was passed by the Congress of

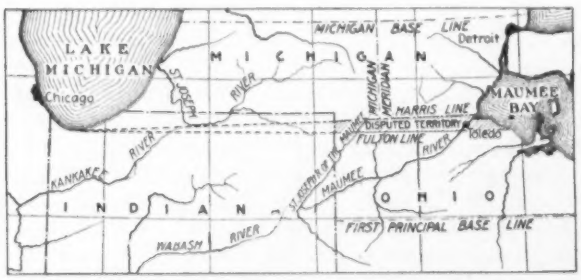



FIG. 1. BOUNDARY OF OHIO AND MICHIGAN WHICH WAS LONG A SUBJECT OF DISPUTE

the Federation. It will be remembered that by this agreement the Eastern States of Massachusetts, Connecticut, New York, Pennsylvania and Virginia relinquished their claims to the Northwest Territory that new states might be formed from it. This Ordinance of 1787 described an east and west line drawn through the southerly bend of Lake Michigan until it intersected the shore of Lake Erie as the boundary between the two tiers of states it was proposed to form.

All the early maps of this region showed the southern extremity of Lake Michigan north of where it should have been, so that it is assumed that the framers of the Ordinance of 1787 believed that they were fixing the northern boundary of Ohio Territory on Lake Erie north of Maumee Bay and even as far north as the mouth of the Detroit River. It was not suspected until 1802, when a convention was drafting the constitution of the State of Ohio, that the southern end of Lake Michigan was some miles south of the east and west line through the north end of Maumee Bay.

So a proviso was attached to this constitution, that if by a geographic determination the southern bend of Lake Michigan extended so far south that a parallel passing through it should not intersect Lake Erie, or should touch the lake east (and south) of the mouth of the Maumee, then with the assent of Congress the boundary was to be a direct line running from the southern extremity of Lake Michigan to the most northerly cape of Miami (or Maumee) Bay. Congress accepted the constitution, but neither accepted nor rejected the proviso. The governor and people of Michigan Territory subsequently insisted on a literal interpretation of the bounds described in the Ordinance of 1787 (and afterward incorporated in the act establishing Michigan Territory), while the new State of Ohio refused to give up its settlement and port on Maumee Bay (afterward the City of Toledo). One result of the controversy was to keep Michigan out of the Union for some time after it was entitled to admission as a state and until it tacitly agreed to relinquish its jurisdiction over the disputed territory. This was in 1837.

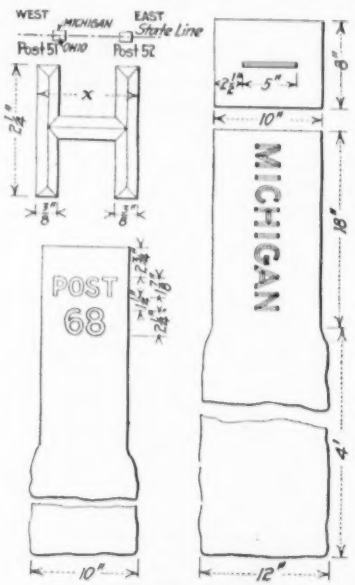



FIG. 2 OHIO-MICHIGAN BOUNDARY MONUMENTS

The disputed boundary was originally surveyed in 1817, according to the Ohio interpretation, for the surveyor commenced at the North Cape of Miami Bay and ran his line westward. Resurveys were made in 1837 and 1842 of portions of the reputed boundary in connection with the surveys of the United States General Land Office. During these resurveys 31 of the original 71 mile posts were found. Nothing further was done until 1915, when a Joint Boundary Commission was appointed and the work of permanently marking the boundary was accomplished.

### Impossible To Locate Original Marks

A preliminary reconnaissance of the line in the summer of 1915 disclosed the fact that none of the original marks or posts, nor those set in 1837 and 1842, were in existence. The western terminus of the line, the northwest corner of Ohio, was identified by a boulder or "niggerhead" buried in the highway. The eastern terminus,

originally the northernmost cape of Maumee Bay, had long since been washed away. It was therefore decided to start at the western terminus and work eastward.

The notes of the original survey (1817) and of the public-land surveys (1837 and 1842) were available, and it was decided to reproduce this line (or lines) as nearly as possible. The usual methods employed in such work, of course, consist chiefly in finding and identifying the original marks; but as already stated, it was out of the question in this case. Therefore, the following scheme of operations was decided upon:

### Program of Procedure

1. As nearly as might be, the line was to be relocated as originally staked out on the ground, and not necessarily run as a straight line from end to end.

2. Existing monuments, fences, highways and other marks, when agreed to by land owners on both sides as being on the state line, were to be so accepted.

3. Field maps of the survey were to be prepared on a scale of 400 ft. = 1 in., showing the preliminary line in red ink, and the location with reference to it of all existing monuments, buildings, highways, property lines and other topographic features (except relief) in black ink.

5. From this atlas of field sheets (one mile shown on each sheet) and the field notes gathered on the preliminary survey, the points where the boundary monuments should be planted were to be determined by a conference of the three commissioners.

6. The final positions of the monuments and the bearings and distances between were to be determined.

7. The latitude and longitude of all monuments were to be determined to the nearest 0.01".

8. In general, monuments were to be planted at each highway and railroad crossing of the state line.

9. Intermediate monuments were to be planted 4 ft. into the ground, the bottoms to be surrounded with concrete 12 in. deep, 2 ft. square, half a sack of portland cement being allowed for each setting.

10. A special monument was to be set at the western terminus (a corner of the three states, Ohio, Indiana and Michigan).

11. No monuments were to be set in an east and west road unless the line made an angle at some point in the road.

12. Monuments were to be placed at all angles in the state line.

### Methods—Instruments—Monuments

In most cases the only feasible method was to accept the General Land Office measurements of the connections made in 1837 and 1842 between the state line and the nearest section and quarter-section corners, north and south. Discrepancies in the figures were prorated.

In one instance the center of a highway for a distance of nearly two miles was taken as the boundary line, because it was so described by the survey notes of 1837, and had been so recognized since. The line as established by the methods employed elsewhere would have been from 71 to 116 ft. south of the center line. In another case a fence line accepted as a compromise in 1907 was taken as the boundary although it was 67 ft. and 75 ft. north of the section corners as determined from the General Land Office records. Two concrete posts on crossings of the Lake Shore & Michigan Southern R.R., which were reputed to be state boundary marks, and which agreed closely with the reëstablished line of 1837, were accepted as final marks.

The instruments used were a transit with 6-in. horizontal circles, graduated to 10′ and read by vernier to 30″, two 300-ft. steel tapes graduated to feet throughout, a 100-ft. steel tape, range rods, plumb bobs, etc. A double-centered transit line was run. Deflection angles were read twice, direct and reverse. This reference or random line was kept as near to, and as nearly parallel to, the original line as circumstances permitted. Distances were measured to the nearest 0.01 ft. with one of the two 300-ft. tapes. Distances were checked to the nearest foot by stadia readings. Azimuth determinations were made from Polaris near sunset.

For marking the line the granite posts shown in the accompanying illustration were used. They were obtained from the Mount Airy quarry in North Carolina and cost $18 each, delivered. Each post weighs about 700 lb., but including the concrete setting; the weight in place exceeds 1,400 lb. A special granite monument with an appropriate inscription was erected on an offset (the actual point being in the center of the highway) from the Western terminus.

The boundary location was settled by three commissioners: C. E. Sherman, Inspector of the Ohio Topographic Survey; R. C. Allen, Director of the Michigan Geological Survey; and S. S. Gannett, of the United States Geological Survey. Mr. Gannett directed the fieldwork and computations. The completion of the fieldwork and the setting of the western monument were celebrated by appropriate ceremonies under the auspices of the Toledo Engineering Society at the site of the monument, Nov. 24, 1915.

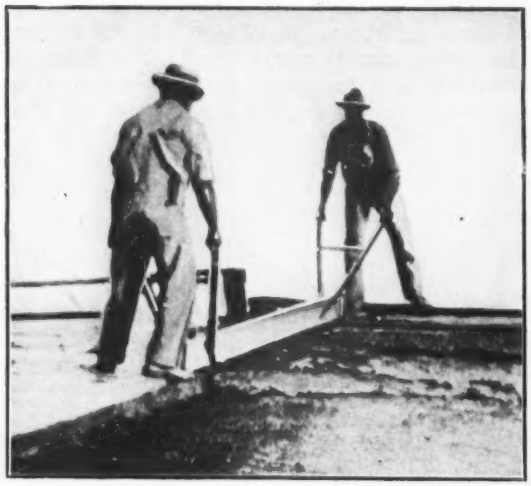
The whole cost of the survey, 69.92 mi. long, did not exceed $7,200, or $102.95 per mi. An automobile was used to transport the field party of six men. The instruments used were loaned by the U. S. Government.

## FINE AGGREGATE

**Care Needed to Prevent Adhesion at Joints**—That the separation on concrete at construction joints intended to localize cracks is not uniformly perfect can be observed in almost any finished piece of work. A typical instance is illustrated by the accompanying photograph. The retaining-wall whose face is represented has no crack or other developed defect in lengths of several thousand feet, except near some of the construction joints, which are spaced about 30 ft. apart. These joints were formed without interposing any paper or other separating material, by pouring one section after the adjoining section had set. No adhesion of any large amount should be obtained under these conditions, yet at places there seems to be a strong enough bond to break through solid concrete alongside the joint. On the wall shown in the picture, most of the joints have the shrinkage crack following straight down the V-groove formed at the face, but a sufficient number of meandering cracks occur to indicate that abnormal adhesion should be reckoned with.—F. S.

A SHRINKAGE CRACK

**A Concreting Screed** which is provided with plow handles at each end is used in concrete pavement practice around Pasadena, Calif. The plow handles make the control of the



PLOW HANDLES EASE UP CONCRETE SCREEDING

screed very simple and at the same time reduce the strain on the men doing the work. The view herewith is taken from a photograph of some paving work on the bottom of a reservoir at Pasadena.

**A Mired Shovel Can Lift Itself** several inches off the ground so that planking can be placed under the wheels. This is done by dropping the dipper to the ground—as illustrated herewith—and starting the crowding or boom en-

SHOVEL LIFTING ITSELF SO PLANKING CAN BE PLACED

gines, and forcing the dipper handle in an upward direction. As the dipper is placed flat on the ground it is impossible to force it below the surface. Consequently, when the boom or crowding engines are started, the shovel is forced to rise off the gound.

**Dumping Rock Off High Trestles**—G. P. Hawley, resident engineer of the Civic Investment and Industrial Co., Cedars, Que., asks for further information concerning the dumping of rock from high trestles (on the Southern Ry. relocation), as described in "Engineering News" of Nov. 16, p. 948, especially whether any end-dumping is employed. B. E. Chewning replies for the Sheahan Construction Corporation that the cars are not end-dumped, but that the 10-car trains are shoved out as far as possible, keeping the dinkey on the fill. Each car is dumped separately, a dog being used to hold the car on the rails. He states that the braces between trestle bents are constantly being broken during rock-dumping, but that this feature is not especially troublesome. Mr. Chewning goes so far as to say, "No successful dumping is ever obtained from end dumping from high trestles; whether dirt or rock. The pressure of the material will push the trestle legs out of place at the ground."

**A Truck and Trailer Hauls 40 Tons per Day** from the mine of the A. A. Haskins Dolomite Co., in San Benito County, Calif., to the railway located 10½ mi. away. The haul is through mountainous country with grades up to 10% and 1½ mi. long. The road is covered with dust from 6 to 8 in. deep. Prior to the present method the dolomite was

HOW TRUCK AND TRAILER ARE LOADED FROM HOPPER

transported by five 8-horse teams hauling 40 tons a day at a cost of $58.21. Now, a 5-ton White truck and a bottom-dump Troy trailer with rubber tires work on 24-hr. service, making four round trips with ten tons each day, at a cost of $28.71.

**Cleaning Old Ballast** is done by the Kansas City Railways by means of a portable rotary screen made out of an old concrete mixer by substituting a revolving screen for the mixing trough and blades. The screen is 6 ft. long and tapers from 18 in. diameter at the motor end to about 3 ft. at the discharge end. The same gasoline engine that formerly drove the mixer now furnishes motive power for the screen. The machine is mounted on a portable steel-wheeled truck. In view of the present high cost of ballast rock, this device is a money-saver.

**Contractor's Compressed-Air Regulations**—In the harbor siphon tunnels of the new intercepting-sewer system at Milwaukee, Wis., the Western Foundation Co. is carrying on compressed-air work under unusually cautious rules. The following times are prescribed for decompression:

| For Pressure (Lb.) | Time of Decompression (Min.) |
|---|---|
| 20 to 24 | 16 |
| 25 to 30 | 20 |
| 31 to 36 | 24 |

The men are required to dry their clothes and drink hot coffee on coming out of the air, suitable facilities being provided. The two tunnels, worked from a joint shaft on Jones Island, are 52 ft. below river surface, and at present are carrying about 28 lb. air. They are in sand, which stands excellently under the effect of the air, so that open face work is done.

# Editorials

## Engineering News Prizes Awarded

In *Engineering News* of Oct. 26 the offer was announced of a first prize of $50 and a second prize of $25 for the best articles on each of four specified subjects, to be submitted to the editors on or before Dec. 10.

The articles submitted in competition for these prizes have been examined and the awards are announced as follows: For papers on the first subject, "Rebuilding with Permanent Surface an Old Macadam Roadway," the first prize is awarded to Charles A. Carruth, of Rochester, N. Y.; and the second prize to Theron M. Ripley, of Watertown, N. Y. For papers describing "Operating Methods in a Drill Sharpening Shop," the first prize is awarded to J. E. O'Rourke, of Granby, Mo.; and the second prize to Frank Richards, of New York City. For papers describing "The Dry Mixing of Concrete Material at a Central Plant," the first prize is awarded to H. F. La Brecque, of Brooklyn, N. Y.; and the second prize to Benjamin Wilk, of Chicago, Ill. For the papers written on the subject, "Adapting the Motor Truck to Its Work," the first prize is awarded to Clarence B. Montgomery, of West Philadelphia, Penn.; and the second prize to Edwin Hall Warner, of Los Angeles, Calif.

The prize papers will be published in early issues of *Engineering News*.

## American Steel Production and Business Prosperity

If one were to form a hasty judgment from the slaughter of prices which took place on the New York Stock Exchange last week, it might well be believed that the conclusion of peace would mean a financial panic in the United States and prolonged business depression. Those who hold such an idea fail to take into consideration the enormous demands which the world will make on all means of production to restore the ruin wrought by the years of war. They overlook the fact that while the war has been going on, the enterprises of peace have been stationary in nearly every country of the world. Houses, railways, mills and machinery have been wearing out and require replacement. It will require years to restore to normal condition the facilities for production in the industrial centers of Europe. To supply the needs of Asia, Africa and South America will make great demands on the productive capacity of the United States.

It is of interest in this connection to note the prophecy of one of the foremost figures in the American steel business, Charles M. Schwab, at a dinner given in his honor in New York City on Dec. 21. Mr. Schwab explained in detail what has been for some time known in a general way, that the Bethlehem Steel Corporation, of which he is the head, has planned a building and construction program involving an outlay during the next few years of about $100,000,000. This expenditure, however, is not chiefly in the enlargement of its great ordnance plant, which is already 50% larger, according to Mr. Schwab's statement, than the famous Krupp Works at Essen. The expansion will be chiefly in facilities for the production of steel for peaceful purposes. "When our plan of improvements is completed," said Mr. Schwab, "the 25 component parts of Bethlehem Steel will consist of only 1 part ordnance making, 4 parts ship building, and 20 parts the manufacture of steel for commercial purposes." The Bethlehem corporation is already building one-third of all the ships under construction in the United States.

As to the outlook for the future, Mr. Schwab said:

> When the war is over there will of necessity be a reduction in the demand for munition steel and there will be some recession in steel prices generally. But the domestic demand for steel rails, for buildings, and for numerous other purposes awaits only a more normal condition of trade to press forward for prompt satisfaction. Those domestic demands alone will absorb our steel capacity for many years. A period of depression will come some time and it may be severe, but it will not become acute, in my judgment, until at least three to five years after the war is ended.

Those who lugubriously picture the United States succumbing to the competition of European rivals after the war forget the terrible handicap of debt under which all productive enterprise in those nations must hereafter struggle. They forget also the vast advantage of the United States in its unrivaled natural resources, particularly in ore and fuel. In steel and iron production the United States has left all other countries far behind. The figures quoted by Mr. Schwab in his address are significant: In 1880 the total steel production in the United States was only 1,000,000 tons. When the U. S. Steel Corporation was formed, twenty-one years later, the annual steel production was 12,000,000 tons, and many believed that we were then at the zenith of the steel business. This year the United States will produce 40,000,000 tons of steel, and Mr. Schwab declared his belief that we are as far from the zenith today as we were in 1901.

## Water Purification Safer Than Sewage Treatment

A principle that is gaining daily in recognition by sanitary engineers is that a dollar spent in water purification goes much farther toward protecting a community from the dangers of sewage pollution in its potable water supply that a dollar laid out in sewage-treatment works. This and some important related principles are well stated in a recently published report on sewage disposal at Davenport, Iowa, by John W. Alvord, consulting engineer, Chicago:

> In general, the expenditures made for the purification of water supplies are much more effective in the protection afforded against epidemic diseases than the sewage-purification works established to protect the purity of the water-supplies. It is immaterial whether a city or private company operates the water-works. If the purification of a water-supply is rendered more difficult and more hazardous by reason of the fact that a city is dumping its sewage in close proximity to a water-works intake, and a water company is

consequently put to additional expense in order to furnish the people with a pure supply, it is only fair that the people compensate the water company in rates for such additional expense. In reality, therefore, the people pay for either water purification or sewage purification. However, a city must not contribute to the pollution of its water-supply when it can be avoided with reasonable expenditures; if it does contribute it must also assume a larger measure of the responsibility of guarding the health of the community.

It is now incumbent on engineers to persuade city authorities to accept and act on these principles.

The time will come when cities downstream from the sewage outlets of other cities will ask that the upstream city bear part of the cost of purifying their water-supplies instead of demanding sewage-treatment works. Intelligent engineers seldom design sewage-treatment works with the idea of affording much protection to public water-supplies and no matter how they are designed, it is common knowledge among engineers that sewage-treatment works are rarely operated under bacterial control.

## Another "Public Buildings' Raid on the Treasury

Every engineer knows that the cost of construction work, due to the great increase in prices of labor and materials, has reached an unprecedented level. Under these conditions, private investors and corporations alike are restricting their work to what is absolutely necessary. The New Haven R.R. Co., for example, recently issued a circular to all its officers, ordering that not only should no new construction work be undertaken but that maintenance work must be restricted to that absolutely necessary to preserve property from deterioration. Those in charge of municipal work also, in many cases at least, understand the importance of cutting down expenditures at the present time in order that work may be undertaken on a liberal scale when the tide has turned. At that time it will be possible to accomplish far more for a given expenditure and at the same time to give employment to labor, which may then need employment badly.

The Congress of the United States, however, is unmindful of these things. A House Committee has reported a bill appropriating $35,000,000 for the construction of public buildings in the United States and the purchase of sites therefor. The bulk of this money is to be spent for the construction of post-office buildings in small villages scattered throughout the country, many of them places of only 1,000 to 2,000 inhabitants.

The raid on the public treasury known as the Public Buildings bill began a number of years ago in a comparatively modest way; but it has rapidly grown bigger and more dangerous year by year. In the last dozen years something like $190,000,000 has been appropriated by Congress for the construction of public buildings. The pending bill is for about $35,000,000 and is likely to have $5,000,000 to $10,000,000 added to it by the time it passes out of the hands of the Senate. Every one of these Government buildings erected in a country town forms a foundation for demands upon the Congressman by rival towns in the district that similar buildings should be erected to ornament them.

In making the appropriations for these buildings, the scale of expenditure is not at all what is needed to properly accommodate the post-office business of the community, but is merely how large a sum can the Congressman secure.

This scandal was investigated in 1913 by a Public Buildings Commission which had among its members Secretary of the Treasury McAdoo, Attorney-General Reynolds, and Postmaster-General Burleson. This commission reported that the post-office buildings which the Government had erected in the smaller towns were so extravagant in cost compared with the rented buildings formerly occupied that the operating expenses of the building alone (to say nothing of the interest and depreciation) amounted to three or four times as much as it formerly cost for rent and care when the post office was in a rented building. This waste in public buildings therefore, means not only taking $35,000,000 out of the Federal treasury to construct buildings at a time when building is very costly but that the Government will be placed under a perpetual heavy expense to operate and maintain these buildings.

Congress proposes to undertake this outlay moreover in the face of the report of Secretary McAdoo showing that the United States treasury will face a deficit at the end of the fiscal year of $185,000,000, and at a time when the need was never greater for Government expenditure on projects of real national benefit.

At this time, too, the Government, like every other great business organization, has to face the necessity of increasing wages and salaries to enable those in its service to meet the high cost of living. Bills to accomplish this have already been introduced in Congress, and it has been estimated that absolutely necessary increases of this sort throughout the Government service will increase the nation's expenditures next year by $25,000,000. Surely, under these conditions an insistent demand should be made upon Congress from all parts of the country that the waste of the public funds in the distribution of "pork," either for public buildings or for river and harbor projects which cannot be justified by national need, must come to an end.

## Practical Bridge Decoration

There has been much talk heretofore about introducing beauty into bridge construction. Pittsburgh will do more than talk. It will spend $60,000 in an effort to achieve an artistic result in the way of combining architecture with the work of the bridge engineer. As to the degree of success of the Pittsburgh effort, every one may form his own judgment from the drawings published elsewhere in this issue. Tastes differ; but even those whose taste is not suited by the Point Bridge portal design will concede that the serious purpose and well studied efforts of the architects in this instance merit more than mere recognition.

There is sharp contrast between the original design for monumental stone portals and the present design in bronze and cast iron. No doubt the taste of many would prefer the stone portal; on the other hand the question of making a harmonious combination of a great steel structure and heavy ornamental portals of masonry overshadowing the structure itself is difficult indeed. When we are further told that the stone portals would have cost very much more than the metal ornamental work now to be constructed, we are likely to agree with the decision of the art expert in favor of the accepted design.

# Letters to the Editor

## Monolithic-Brick Pavements

Sir—In a notice of the new specifications of the National Paving Brick Manufacturers' Association, on p. 945 of *Engineering News*, Nov. 16, 1916, it is stated:

> The following paragraph provides for the dry mixing of one part cement to three parts sand, and it is presumed that this mixture is applied dry to the foundation concrete, although the specifications do not definitely say so. The brick are laid, rolled and grouted as in ordinary practice.

I wish to call your attention to the fact that this point is covered in Item 5, Sec. 5, of the country road specifications, the second paragraph of which reads:

> In shaping the concrete deposited from the mixer, it shall be thoroughly spaded, settled and roughly surfaced immediately ahead of the double templet. A sufficient amount of dry mixture for the thin coating shall be supplied continually between the framed templets so that in the forward movement, the rear templet shall distribute the necessary film over the entire surface, producing the required smoothness.

It is here clearly stated that the dry mix shall be applied immediately to the green concrete. This process is further explained in the note included in Item 5, treating of the "Concrete Foundation," which definitely states how this film of dry mixture becomes an integral part of the concrete.

You also state that "the brick are laid, rolled and grouted as in ordinary practice." In Item 8, Sec. 6, we tried to state very definitely how the brick pavement shall be rolled and brought to the required surface. This process differs from the ordinary practice in that we use a hand roller weighing not less than 20 lb. per inch of length, the length required being approximately 30 in. Similar provisions are made in the city street specifications under different items and sections.

WILL P. BLAIR,
Secretary, National Paving Brick Manufacturers' Association.

Cleveland, Ohio, Nov. 18, 1916.

## Patents in Municipal Contract Specifications

Sir—For many years municipal contracts have contained a clause designed to protect cities against claims for patent infringements. The plan has been to require the general contractor to assume all responsibility for defending such claims and for any cost and damages arising therefrom.

The evident original intent of such clauses was to protect cities from any patent claims which were held by other than the guarantor and with which the city was not familiar. It is doubtful whether such a standard clause in specifications would cover a direct patent obligation unless prospective bidders are notified in advance what the patent fee is, so that it may be included in contractor's bids.

The Imhoff tank has been offered to the American public for very moderate royalty fees, based on the population tributary to the tanks. It would appear to be necessary for an engineer drawing his specifications, or for a city building Imhoff tanks, either to specify the amount of the fee in the specifications and to whom it shall be paid, and to demand a receipt from the contractor before settlement for the work is made, or else to eliminate the Imhoff royalties from the general contract and so state in the specifications, at the same time specifying that the city will pay the Imhoff fee direct. Obviously, if the city pays the fee for a recognized patent claim, as covered by the contractor's bid, it (the city) should have and hold the license to operate the patented process or apparatus—the city's interest in the matter not being protected in any way, otherwise.

S. FISHER MILLER,
President, Pacific Flush Tank Co.[1]

Singer Building,
New York, Nov. 23, 1916.

## Patents and War!

Sir—I have no patents and do not want any, but I think you treat inventors unfairly. You encourage the boys to poach on old men's ideas. The old engineers are in the scrap pile. Employers want fresh young hothouse graduates, directors' sons, who know not how to criticize, but can marvel at their superior's ability and laugh at his jokes. The old man built structures that stand and earn dividends. They like his work, but dislike to pay him. The kid can copy his plans and make a reputation for himself if the judge will only knock out patents.

They are your subscribers and you serve them well in chuckling as you do over every patent killed. In your last issue you were happy because a filter patent was invalidated at Minneapolis, and in the same paper you wish someone would invent a water-pipe joint to be knocked out! I would invent a pipe joint if I did not have to advertise, compete with the old joint, hire lawyers, experts and detectives to dig up and expose infringements.

No one is punished for this kind of theft. If he is caught, he only has to pay the regular royalty. Judges mistake public feeling if they do not give inventors the benefit of doubts and rely upon patent-office examiners rather than experts who do not care which side of a case they are on.

Last spring I sent you a patentable idea about range finding for artillery. I wanted it published only in the interest of my three boys and others who may be exposed to artillery fire, due to the lack of engineering knowledge in the army. But you refused, because you are a "pacificist"; and I hope the first hostile shell will fall on your desk.

There you sit on Manhattan Island, an engineer, and imagine yourself safe behind the disappearing guns. Can they be elevated for a maximum range? If not, is not the defect fatal? Do you think there is something mysterious that will bluff foreigners? It is your duty to expose the weakness of those guns and to advocate laws to reorganize the army, on the theory that war is engineering, far more so than was understood last spring. It is all artillery. In-

[1] American and Canadian commercial representative of Dr. Karl Imhoff, Essen, Germany.

fantry is now only an adjunct. You would not reject my idea at this time, especially if you could see the October minutes of the General Staff, where they gave me a resolution of commendation for it and said it was successfully tried in the great war.

The future successful commander must be an engineer and rely almost exclusively on artillery. He must study topography more than an engineer ever has; he must figure trajectories and fix locations by trigonometry and drafting, must understand what explosive forces he controls, muzzle velocities, atmospheric resistance, must call out the coöperation of his subordinates and keep records and data as only an engineer can do.

Strength is not in men, but in engineering. The old idea of an army is long lines of glistening bayonets, but these are out-of-date and useless. In their place are picks, shovels and grenades to hold and herd the mobs at a distance from the batteries; and it is your place to say so.

Your brother journalists who are not engineers may be excused in thinking your guns with complicated casting support are safe in a pit, that the shells will come like beams of light, on a straight line, or that all the lives and ammunition that are wasted in France cannot be avoided by science. You ought to know better.

Denver, Colo., Nov. 15, 1916. A. M. Haynes.

[We trust no large proportion of our readers have as peculiar ideas as to the editorial conduct of *Engineering News* as those so forcibly expressed by our correspondent. Their publication, however, affords an opportunity to correct misconceptions that may have been shared by others. *Engineering News* has no quarrel with patents on real inventions. Careful reading of our columns will show that our criticisms have invariably been aimed, not at legitimate patents on bona fide inventions, but at patents that have been issued for mere variations in design, such as could have been made and have, in fact, been made by other competent engineers and for which the grant of a monopoly right is not justified.

As to his reference to the young engineer as a supplanter of the old inventor, in nine cases of ten it is the "fresh young hothouse graduate" who tries to get a paper patent on some alleged invention and occasionally, by so doing, makes a deal of trouble for the old engineer, who knows that it is the business of an engineer to solve the new problems in design that come before him as part of the day's work and that it is against public policy and unprofessional to claim a monopoly in his solution of such a problem unless he has really made an important advance in the state of the art.

To take the pipe joint for illustration, it would be extremely difficult to invent anything in the way of a new pipe joint on which a valid patent could be obtained, in view of the hundreds and thousands of pipe joints already on the patent records. What is needed is not a new invention, but a thorough scientific study of past and present practice in making pipe joints and the development of such detailed methods and improved materials that it will be possible for engineers responsible for building pipe lines to produce a much higher grade of work.

Turning now to our correspondent's remarks on military engineering, it is to be hoped that every contribution that the editors of *Engineering News* find it necessary to return to the author does not provoke such lurid wishes toward us. At least he should be more considerate of our innocent desk neighbors.

We find no record of the receipt from him of any such contribution as he describes; but if it was received, it would have been of necessity returned under a rule of over 25 years' standing that new inventions are not described in these columns until they have been actually constructed and tested.

Further than this, *Engineering News* is obliged to set certain limitations to the field that it can cover, and it can devote little space to matters of military engineering, important though that is with respect to the national security. Notwithstanding his convictions as to our "pacific" tendencies, we take pleasure in congratulating him upon the compliment to his range-finder invention and express our hearty approval of certain of his criticisms with respect to weak points in our national defense.—Editor.]

## Cost of Concrete and Other Permanent Pavements

Sir—In an editorial, with the substance of which the writer is in accord, published in your issue of Nov. 23, entitled "Blundering Road Legislation in New Jersey," you state that "with a minimum width of 18 ft., there would be at least 10,560 sq.yd. of paving to be laid per mile; and of the materials specified as permissible for the paving, concrete is the only one that could possibly be brought within this limit of expense." There is a previous statement that the permissible expenditure must be less than $13,000 per mile.

The inferences to be drawn from these statements are that an 18-ft. concrete road can be built for less than $13,000 per mile; and that if a road of any other type were to be built at this figure or under it, it would not correspond to the highest standard of construction recognized as essential to success.

The writer believes that neither of these inferences is correct. In the tenth annual report of the Board of County Commissioners of Wayne County, Michigan, just issued, the cost of a one-course road 18 ft. wide, 1.29 mi. in length, figures out at the rate of $16,120 a mile. A 15-ft. road (Canton Center Road) cost $17,380 a mile. A two-course road 3.8 mi. in length and 18 ft. wide cost $24,140 a mile, the greater cost in the latter case being attributed to the use of stone in place of gravel. In all these cases the costs do not include profit. In other words, they would undoubtedly have been greater if the road had been built under contract.

The tabulation of the bids received recently by the State Highway Department of New York, presumably based on a 16-ft. road, gives costs of from $13,000 to $20,600 and an average cost of $15,700 per mile, exclusive of overhead charges, which would bring the cost to about $17,300 per mile. A recent proposal received by the writer amounted to $19,900 per mile.

The "Tabular Digest of Some Concrete Pavements," by the Association of American Portland Cement Manufacturers, shows that the prices per square yard varied from $1.22 to $1.62, and the writer knows of a case where the price this summer has been as high as $1.74 per sq.yd. On the basis of 10,560 sq.yd. this would give costs of from $12,900 to $18,400 per mile, exclusive of the necessary grading, indicating clearly that, on account of the cost alone, concrete would have to be excluded from consideration rather than that it is the only pavement that may reasonably be considered.

The implication that other types of permanent pavement cannot be built for $13,000 or less is not justified if it is admitted that a bituminous pavement on an unyielding foundation comes within the requirements of the statute. The State Department of Highways of New York builds such roads quite extensively, and a tabulation of bids recently received gives prices ranging from $11,500 to $13,100 per mile on 36 mi. of roads. The writer has personally built many miles of permanent roads of a similar type, the cost of which did not exceed $13,000 per mile.

EBERHARD J. WULFF.

Tarrytown, N. Y., Dec. 4, 1916.

[The New Jersey law referred to specifies that the roads are to be paved with "granite, asphalt or wood blocks, brick, concrete, bituminous concrete, asphalt or other pavement having a hard surface and of a durable character."

In the comment that our correspondent quotes, we did not say that these roads could be built and paved with concrete at an average cost of $13,000 per mile. We said, "of the materials specified as permissible for the paving, concrete is the only one that could possibly be brought within this limit of expense"—which is quite a different thing.

If $13,000 were spent solely on the paving of a road one mile long and 18 ft. wide, the average expenditure would be $1.23 per sq.yd. It is needless to say that paving of granite, sheet asphalt, asphalt block, wood block or brick cannot be laid at this price per square yard, and the only materials left are concrete and "bituminous concrete." According to the standard definition, "bituminous concrete" refers to a road pavement of bituminous materials and hard aggregate mixed together before placing on the roadway. Many of the roads paved with bituminous concrete by the mixing method have cost $1.50 to $2.00 or more per square yard. The cost of such roads has it is true been considerably reduced but it is doubtful whether it could be brought within the limit above stated.

The only remaining material specified is concrete. The cost data on concrete-road construction reported by a special committee to the Concrete Road Conference of last February showed average costs per square yard for concrete roads in 1915 in some of the states as follows: Connecticut, $1.13; Illinois, $1.03; Indiana, $0.98; Maryland, $1.08; Massachusetts, $0.95; Michigan, $1.10; Minnesota, $1.11; Missouri, $1.09; New Jersey, $1.23; New York, $0.98; Ohio, $1.02; Pennsylvania, $1.01.

Considering the abundance of good stone, gravel and sand in New Jersey and its nearness to the cement mills, good concrete pavements should be laid in New Jersey for about a dollar per square yard, under normal conditions in the labor and materials market, although not at the inflated scale of prices now prevailing. As stated in the article, however, other items in the cost of reconstructing the proposed roads would raise the cost per mile far above the $13,000 limit.—Editor.]

## Long-Time New York Rainfall

Sir—The articles entitled "Long-Time New York Rainfall as Basis for Sewer Design," by O. Hufeland, in your issues of Aug. 31 and Sept. 7, 1916, have been read with interest. The precipitation record of the Central Park Observatory is of great value and *Engineering News* is to be congratulated for having made it generally available to the profession. The previous publication in the progress report of the Committee on Rainfall and Runoff of the Municipal Engineers of the City of New York[1] was unknown to many engineers, and somewhat difficult to obtain. Mr. Hufeland appears to have presented the data in somewhat more detail, and his diagrams are reproduced to a larger scale than those of the Committee. It is noticeable that he presents exactly the same formulas for intensity of precipitation of various frequencies as those reported by the Committee, yet makes no reference to the Committee or its report.

Mr. Hufeland's characterization of the analysis in his first article as the "average-rate" method, particularly in connection with his statements, seems to the writer unfair. He says:

> The reasoning on which these curves are based is that storms that have occurred but once in 45 yr. will probably not occur again in a shorter period; those that have occurred twice in 45 yr. may be expected to occur every 22½ yr., etc.

Everyone knows that the occurrence of extreme rainfalls is very erratic, and that three or four extreme storms might occur in a single year. If the intensity were not equalled again for a century, the (average) frequency might be 25 yr.; but this is only a relative statement, and a similar or equal storm may occur again at once.

Mr. Hufeland's argument for what he calls the "uniform intensity" method is not very convincing. It is seldom that storms of considerable intensity maintain a uniform intensity for any considerable time; but they do occur, and their effect must be allowed for in sewer design. According to Mr. Hufeland's argument, storms in which the intensities are not substantially uniform will be left out of consideration. It is probable that most storms in which the intensities are sufficiently uniform so that anyone would use the average, would have nearly as great an effect in producing runoff as absolutely uniform storms with the same average intensities, and it is conceivable that, with certain conditions of variation of intensity and shape and slopes of the drainage district, the non-uniform rain might produce the greater runoff.

It is significant to compare the maximum intensity curves given in Mr. Hufeland's two articles. As shown in the table below, the intensity for which a drain serving a district having a 20-min. period of concentration would be designed would be only half as great, and for a 60-min. district, only about a third as great as if the "average-intensity" method were employed.

COMPARISON OF MAXIMUM INTENSITIES OF PRECIPITATION AT NEW YORK ACCORDING TO TWO METHODS

| Period Minutes | Intensity of Precipitation, Inches per Hour: Average Intensity | Uniform Intensity |
|---|---|---|
| 5 | 11.81 | 12.00 |
| 10 | 9.30 | 6.55 |
| 15 | 7.90 | 4.50 |
| 20 | 6.85 | 3.42 |
| 30 | 5.43 | 2.32 |
| 40 | 4.48 | 1.76 |
| 50 | 3.82 | 1.41 |
| 60 | 3.33 | 1.18 |

Mr. Hufeland himself confesses that he has no substitute to offer for the so-called "average-intensity" precipitation curves when it comes to the actual use to be made of them; that is, he does not argue that the "uniform-intensity" rate curve should be substituted in design. If this were to be done, the sub-mains might be of ample size, but it seems obvious that the main drains would be woefully inadequate.

CHARLES W. SHERMAN.

Boston, Mass., Dec. 18, 1916.

[1] Proc. Munic. Engrs., New York City, 1913, p. 373.

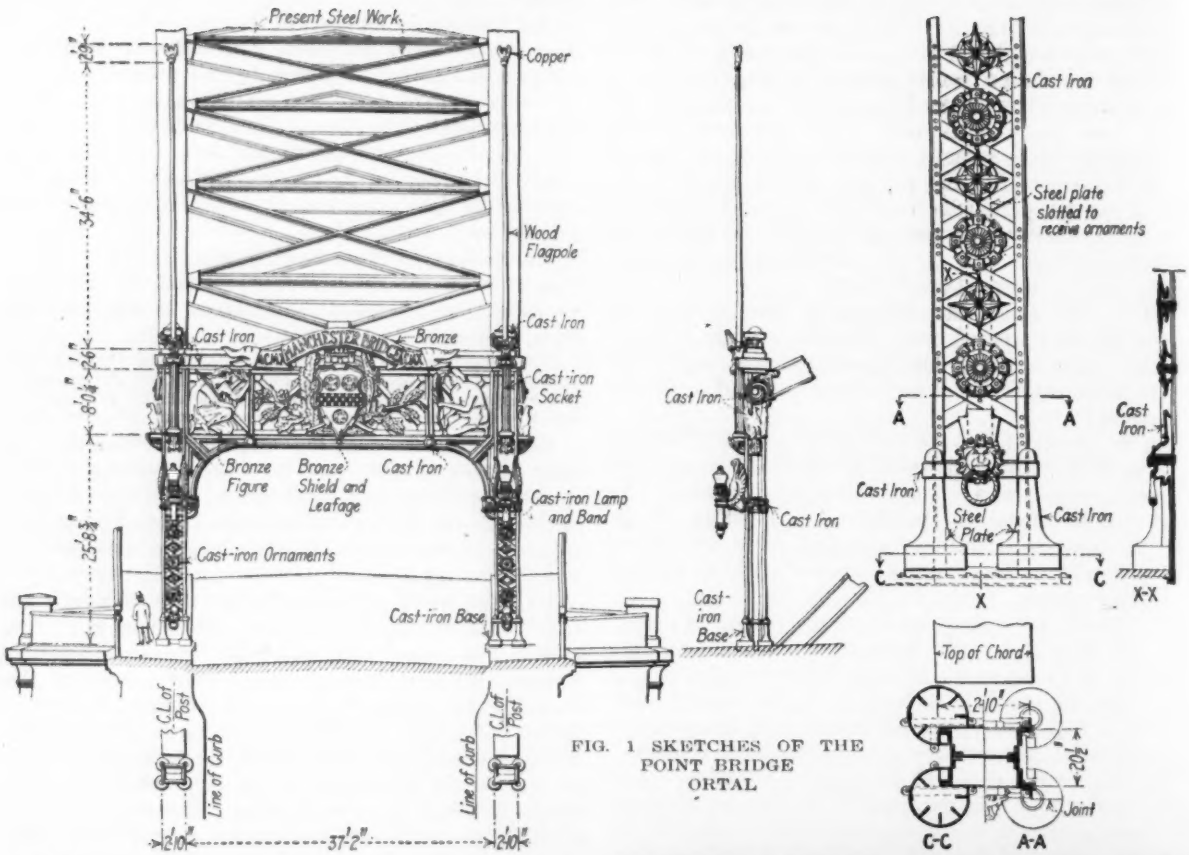



FIG. 1 SKETCHES OF THE POINT BRIDGE ORTAL

## Elaborate Ornamental Portals for Point Bridge

Highly sculptured ornamental portals are to be added to the North Side Point Bridge, Pittsburgh, at a cost of about $60,000. Stone archway portals were designed for the structure originally, but for various reasons, principally that of cost, the stone design was abandoned. The new plans are the result of a year's study by the city's Department of Public Works, in coöperation with the Municipal Art Commission, whose approval was necessary. The general plans were shaped mainly by S. L. Roush, architect of the department, in collaboration with the sculptor selected for the work, Charles Keck, of New York City.

Several drawings and a photograph of a small-scale model of one portal are reproduced herewith. The steel portal to which the ornamental work fastens is already in place, being part of the original design. Though the bridge (two 515-ft. spans) is of regular curved-chord type, with inclined end-posts, a vertical portal was provided at each end, with posts footing over the end pins; and the top lateral system was extended out to this portal in order to deliver the wind shear to it. The steel portal was to form the central core of the ornamental stone portal, and the designers held the view that by actually transferring the wind forces to the plane of the vertical portal the stone portal would place true emphasis on a structurally vital element—namely, that which secures the stability of the bridge.

The stone portal would have concealed the steel portal, but the new cast-iron and bronze portal utilizes the

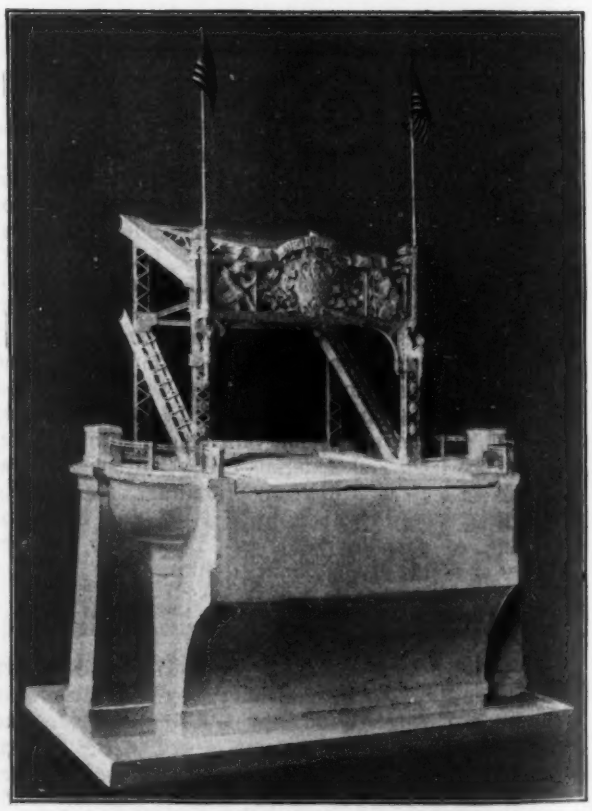


FIG. 2. PHOTOGRAPH OF MODEL MADE BY CHARLES KECK, SCULPTOR

general outline and appearance of the steel portal, with the addition of surface ornamentation. "It was the idea," states the architect, "to evolve an ornamental metal portal which would harmonize with the steel structure, all needed structural members to be shown and the ornamental parts made subordinate to them."

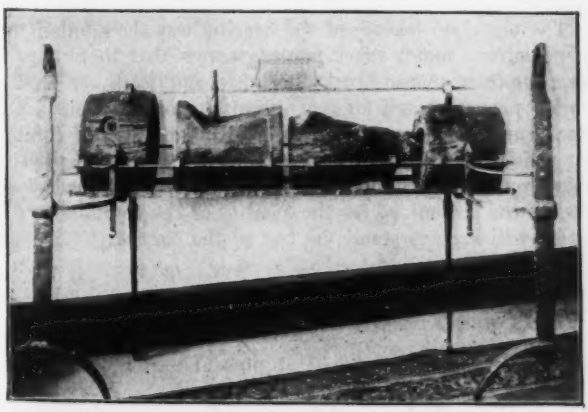
The evolution of the design by coöperative effort was about as follows: Sketches for various possible portals were prepared by the department and submitted to the Art Commission. The latter, after several conferences, selected the design that promised the most successful result. Fuller drawings were made for this design, and the development of the main ornamental elements was elaborated in conference with the sculptor; a ½-in. scale model was built up in the course of this work. The Art Commission passed on the model and suggested a few changes, after which contract plans were drawn up and construction contracts let. The further process will be to prepare quarter-size models for final criticism and revision, and then full-size models for the foundry's use.

The figures in the portals are intended to be based on local historical or industrial life. The finished work is expected to have not only artistic value, but also an educational effect.

The cost of the two portals is $45,100. Some changes in the present steelwork at the portals to receive the ornamental work will add about $15,000 to this figure.

## Early Water-Works Relics

Relics of New York City's early water-works continue to be unearthed in connection with the subway construction. The William St. subway, passing through the ancient part of the city, furnished the interesting relics illustrated herewith. The pieces from left to right are a service connection, a gate valve, and a bell-and-spigot joint. They were mounted as shown and presented to the



SERVICE-PIPE CONNECTION, GATE VALVE AND BELL-AND-SPIGOT JOINT ON OLD WOOD WATER PIPE

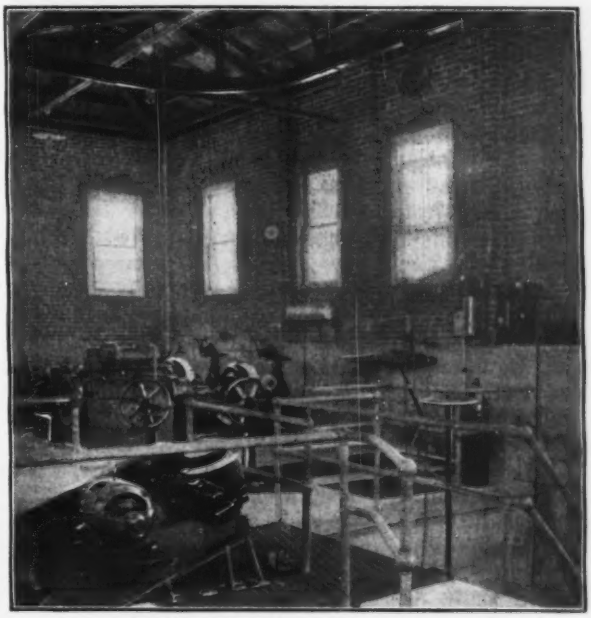
Engineers Club of New York by F. J. MacIsaac, of Smith, Hauser & MacIsaac, Inc., contractors.

These are supposed to be relics of the water-distribution system of the Manhattan Co., and may have been installed in the last decade of the eighteenth century. There is a fair chance, however, that they are a part of the system of the first water-works company, which was in operation in 1776, with Christopher Colles as superintendent. This company ceased operation during the Revolution.

## Screening and Disinfecting Wildwood Sewage

A plan for treating the sewage of Wildwood, a seaside town in southern New Jersey, has recently been put in operation. Fine screening followed by liquid-chlorine gas disinfection is employed. The effluent is discharged into Grassy Sound.

By treating the sewage while fresh and by a process that breaks down a comparatively small percentage of



INTERIOR OF WILDWOOD SEWAGE WORKS

the solids, clarifies and then disinfects the sewage, it was possible to locate the plant near the cottages and other buildings served, and discharge the effluent into near-by water. This, of course, saves materially on the length of sewer pipe required.

Two Riensch-Wurl screens are used, each 10 ft. in diameter. The screen disks are of rolled manganese bronze, with specially cut slots for perforations $\frac{1}{16}$ in. wide by 2 in. long. The solids removed by the screens are automatically discharged into cans that are lifted by a hoist and conveyed by a trolley to a point outside the building from which they are carted away.

The sewage-treatment plant and the sewage pumps are housed in a small building, the interior of which is shown by the accompanying view. The pumping equipment consists of three 10-in. D'Olier centrifugal pumps, two of which are operated by direct-connected electric motors and one by a direct-connected gasoline engine.

The plans and specifications for the plant were prepared by Harry E. Weir, city engineer of Wildwood. James McLinden & Co., Anglesea, N. J., was general contractor. The screens were supplied and installed by the Sanitation Corporation, New York City.

**Wisconsin State-Aid Roads** constructed during the present year amount to 1,158 mi., costing $3,631,026, according to A. R. Hirst, chief engineer of the State Highway Commission. Besides the roads there were 352 state-aid bridges, which cost $540,068, making a total expenditure of $4,171,094 for the season.

# News of the Engineering World

## Interesting Report on Ohio Topographic Survey

The recent completion of the topographic survey and map of Ohio, by the U. S. Geological Survey in coöperation with the state, marks the termination of the most extensive and rapid state topographic survey yet made in the Union.

The work was begun in 1900 and completed in 1916. The total area of the state, all mapped to the standard scale of 1:62,500, is 41,240 sq.mi., or more than the combined areas of Massachusetts, Rhode Island, Connecticut, New Jersey, and Maryland, which have previously completed similar topographic surveys. West Virginia has also been completely surveyed, but a large portion of its area is mapped to a scale of only 1:125,000.

The entire State of Ohio has been completed in 16 years. In contrast Maryland, the next largest state completed to the Government's standard scale, began coöperation in 1896 and completed the work in 1915. New York began a similar survey about 25 years ago and at the present rate will not be through for several years. Pennsylvania, which began coöperation before Ohio, is not much more than half done, while the other large states have done little more than make a good beginning.

The state's share in the coöperative survey of Ohio has for the past 15 years been under the direction of Prof. C. E. Sherman, who plans to get out a final report in four volumes.

Volume I, entitled "The Ohio-Michigan Boundary," is just out of press, and is a formal report for adoption at the forthcoming session of the legislature. The work of relocating and monumenting the boundary was done in 1915 jointly by the States of Michigan and Ohio, and the only action remaining to be taken is formal approval of the joint report now submitted by Michigan and Ohio.

Volume II, "Description of Surveying Marks and Monuments Used in Making the Topographic Survey of Ohio," will contain about 700 pages, and is printed up to page 500. This volume is a revised and edited compilation of the field notes gathered in the state by Government surveying parties, supplemented by similar notes from railroads and cities where they are sufficiently precise.

Volume III, "The Public Land Systems of Ohio," is in preparation. Since Ohio was the experimental ground for the Union in developing the present system of sectionizing public lands, the commonwealth presents more varieties of subdivision than any other state in the Union.

Volume IV, entitled "The Progress and Completion of the Ohio Topographic Survey" is planned as a popular description of the work. It will include chapters on origin of the survey, with a complete list of previous maps of the state; legislation, agreement, and expenditures; methods of surveying used; record of progress; uses of topographic maps; boundaries of the state; land and water areas, etc.

Without a single failure from the beginning to the end of the field work, the legislatures of Ohio have appropriated the necessary funds for coöperation with the Government, and the forthcoming session is expected to appropriate sufficient funds to complete the final report as above outlined.

## Final Hearing on New York Motor-Truck License Law

The New York State commission appointed by the legislature to adopt and file a schedule of fees to be paid by the owners of motor omnibuses and motor trucks held a second and final hearing in New York City, Dec. 21. The first hearing at Albany, Nov. 21, was reported in this journal, Nov. 23. Little new or of interest was developed at the second hearing. The commission has seen fit to give no inkling of what the proposed schedule is to be, and the meeting was devoted largely to a repetition of the previous arguments against any special taxation whatsoever.

A. J. Slade, of the Society of Automotive Engineers, stated that this society had studied the problem of basing fees on the "time and extent of the vehicles' use of the roads and the relative wear and tear on the roads resulting from their use" (according to the definition of the law) on four separate occasions covering several years, and that each time the task had been abandoned as impracticable. A formula for computing fees on such a basis was possible but too complicated to be generally applied.

The principal feature of the hearing was the admission of prominent motor truck manufacturers that there must be a limit to motor trucks, weights and loads, at least under present conditions of highway construction. A maximum of 14 tons was mentioned as a practical limit for weight of truck and load combined. It seemed probable from the discussion that if any attempt is made to change the present $5 fee the legality of the commission's action will have to stand the test of the courts.

## Volcano Develops 15000 Hp.

In Italy the price of coal at present varies from $40 a ton at seaports to $50 in the interior. In central Tuscany near Volterra this economic pressure has resulted in the erection of a large electric plant operated by subterranean steam from a volcano. There are here numerous cracks in the ground, from which powerful jets of steam constantly spout high into the air. These are known as *soffioni* (blowers), and for many years boric acid and borax have been extracted from the steam.

This steam is now used for generating power. According to Professor Luiggi, in *Engineering*, credit for this use of the steam on a large scale is due Prince Ginori-Conti, who has been experimenting in this district since

1903. Holes from 12 to 20 in. in diameter were bored in the ground, and pipes were driven down to the source of the steam, which is under a stratum of hard rock 300 to 500 ft. below the surface. The steam issues from these holes at pressures of two to three atmospheres and temperatures of 150° to 190° C. New borings do not seem to affect the supply, so long as the distance apart of the holes is not less than 50 ft.

It was attempted to use the steam direct to drive a 40-hp. steam engine, but the borax salts and the gases mixed with the steam, especially sulphureted hydrogen and traces of sulphuric acid, had a corrosive action on the metal parts of the engine. The difficulty was got around by applying the superheated volcanic steam to a boiler; that is, substituting it for fuel in an ordinary multitubular boiler in which steam was produced at a pressure of two atmospheres, then passed through a superheater where it was dried by volcanic-steam heat and was then used to drive a 300-hp. condensing steam turbine, directly connected to a three-phase electric generator, which supplies the works and villages around about Larderello.

This plant proved so successful that, when the war broke out and prices of coal soared, Ginori-Conti decided to carry out the work on a large scale. Three 3,000-kw. turbo-generators were ordered, from the Tosi works of Legano, designed to operate with superheated steam at 1½ atmospheres, generated in specially constructed multitubular boilers having aluminum tubes for the better utilization of heat and better resistance against corrosive action of the volcanic steam. In the boiler the steam temperature was reduced from 180° to about 120° C., and borax was extracted from the exhaust.

One of the 3,000-kw. units has been at work since January, 1916, the second since April, and the third has very recently been put into service. The three-phase electric current is generated at 4,500 volts, 50 cycles, and stepped up to 36,000 volts for transmission to Florence, Leghorn, Volterra, Grosseto and other towns in Tuscany.

## New Shop Instruction Method Tried at University

To reduce the amount of instruction necessary in the engineering shops and to save students' time, an interesting scheme of shop instruction has been worked out by William L. Dabney, shop instructor at the University of Wisconsin.

That experience gained in one line of work can be carried over into a new kind of work in the particulars in which the two are similar (the principle formulated by Prof. Edward L. Thorndike, the well-known psychologist) is the basis. The scheme worked out by Mr. Dabney picks out the points of likeness in all the machines which the students must learn in the shops and arranges the work so that the student does not have to start at the beginning in learning each new machine, but can carry over some of the experience gained in previous work.

Experimenting done on the work of students in the engineering shops at the university showed the value of the plan. The results of the experiments have been written up in the form of a thesis and later will probably be put in a form suitable for the use of all shop instructors.

**Bigelow Boulevard** is the name given the former Grant Boulevard, Pittsburgh, Penn. The name has been changed by a city ordinance in honor of the late Edward M. Bigelow, M. Am. Soc. C. E., who was Director of the Department of Public Works for many years. The boulevard which now bears his name was laid out and constructed during his administration.

**The Air Breakwater** that protects the Standard Oil pier at El Segundo, Calif., described in "Engineering News," June 22, 1916, p. 1166, was recently completed at a cost of $10,000 for the 1,700 ft. of pipe involved. The pipes are 4-in., having ¼-in. perforations 6 in. apart. A compressed-air plant furnishes air to the pipe system, and it is this air rising through the water that is intended to calm the surface sufficiently for loading or unloading the tankers.

**The Old Slip South Tunnel** headings were holed through on Dec. 19. This is one of the eight new rapid-transit railway tunnels being built under the East River at New York. The Old Slip pair of tunnels will connect the Seventh Avenue Subway, which extends through Varick St., West Broadway, Park Place, William St. and Old Slip, with the Brooklyn subway lines of the Interborough Rapid Transit Co.'s present subway system, via the river tunnels, Clark St. and Fulton St. The tunnel is being constructed by the Flinn-O'Rourke Co., of New York.

**Completion of the Engineer Post and School** of the United States Army at Washington Barracks is recommended by Gen. W. M. Black, Chief of Engineers, and estimated to cost $202,500. This includes $125,000 for an administration building (housing also laboratories, printing shop, etc.), $55,000 for completing the West barracks and moving the hospital, $20,000 for a quartermaster's corps barracks and $2,500 for a fuel shed. A $100,000 school building has already been erected. Engineer troops and officers are trained here; all items of engineer equipment for the seacoast defenses of the country and possessions are purchased and distributed from here.

**A Proposed Water-Power Law** to take the place of those now pending in Congress on which a deadlock seems likely was suggested to the President by Secretary Lane on Dec. 21. The proposed law reads as follows:

> The Secretary of War, the Secretary of the Interior and the Secretary of Agriculture shall compose a Water Power Commission. This commision shall have power to grant leases for the use of all public lands (including reservations) and navigable streams for the development of water power under such terms and conditions as shall be by them prescribed by general regulation, no such lease to extend for longer than 50 years.

Secretary Lane suggests that this act would eliminate all controversy in Congress over details, and by the regulations imposed the Commission could impose everything that is sought by the Ferris, Myers, Adamson or Shields bills.

**Enlargement of the Bethlehem Steel Corporation** was described by Charles M. Schwab at a dinner in New York on Dec. 21. In 1915 the Corporation employed 23,000 men, the total pay roll was $22,500,000 and the average earnings of each wage earner were a little over $900 per man. In 1916 the corporation employed some 70,000 men, the pay roll is about $72,000,000 per annum and the average earnings are nearly $1,200. The Corporation has undertaken to construct at a cost of $4,500,000 a plant to build 16-in. guns. In remarks by the president of the company, Eugene G. Grace, he stated that when Mr. Schwab went to Bethlehem the town had 13,000 inhabitants; today the employees of Bethlehem Steel alone are sufficient to make a city of 150,000 people. Ten years ago the annual sales of Bethlehem products were $10,000,000. Last year they were $230,000,000.

**Two Iowa Railways** have recently been abandoned, the Chicago, Anamosa & Northern, a line 35 mi. long in eastern Iowa, which was built in 1903-04 and never earned anything but a deficit. Two years ago the road was sold under judgment proceedings and the purchaser has now sold the entire outfit, including rails, bridges and rolling stock, for shipment to the war zone. The Atlantic, Northern & Southern Ry., in western Iowa, a 37-mi. line which was built in 1910 largely by labor contributed by the farmers living along the line, has been in financial difficulties ever since its construction. Its operation was stopped on Dec. 31, 1914. The Iowa Railroad Commission, in response to a petition by those living along the route, ordered a part of the line to be operated, but this order was annulled by both the State and Federal Courts. On Dec. 9 the Federal Court issued a decree authorizing the dismantling of the property and the sale of the rails and rolling stock.

**Damage Suits Follow Dam Failure**—In an endeavor to decide the liability of the City of San Diego, Calif., for the destruction of property in the Otay Valley at the time of the failure of the Lower Otay dam on Jan. 27, 1916, a test case has been filed in Los Angeles by Mrs. Mary H. James, asking for $10,763.85 for damages to her orchard. Until this suit is ended

other damage suits amounting to over $500,000 will be held in abeyance. There are about 60 of these. In Mrs. James' complaint she alleges the dam was faultily constructed; the slopes of the fills were inadequate and too steep to support the dam against the rush of waters; the iron core walls of the dam and the concrete walls were of inadequate dimensions; the dam was not protected by suitable spillways; the blow-off valves were improperly constructed and the material used in the construction of the dam was of inferior quality The suit is expected to be one of the most involved and most costly ever participated in by the City of San Diego. The suit is brought in Los Angeles because of the provisions in the statutes requiring such cases to be tried outside the county in which the defendant resides.

**Progress on the Calaveras Earth Dam,** which will be when completed the highest earth dam in the world, was described by T. A. Elliott, engineer of the Spring Valley Water Co., before the San Francisco members of the American Society of Civil Engineers on Oct. 17. The dam when completed will contain 3,100,000 cu.yd. of material, will have a height of 240 ft. above bed rock, a crest length of 1,300 ft. and a base width of 1,300 ft. The upstream slope is 1 on 3; the downstream slope 1 on 2½. Practically all the material placed in the dam by hydraulic fill has been pumped. In only one of the eight borrow pits was the elevation sufficient for material to be carried to the dam by gravity. The material placed by hydraulic fill has been carried from 1,000 ft. to 4,500 ft. Two shifts of men per day are worked; the total force is 60 men. With this force an average of 3,600 cu.yd. of material per day has been excavated and placed in the dam, being transported an average distance of 3,000 ft. The direct cost of sluicing the first 1,000,000 cu.yd. of fill was about 25c. per cu.yd. This is the operating cost and does not include interest, overhead, superintendence, insurance or auxiliary cost of building roads, trails, camps, etc. The dam is now completed to 140-ft. elevation and contains 1,750,000 cu.yd. At the present rate of progress the dam will probably be finished in 1918. According to present indications, the total cost will be about $2,500,000. The work on the dam was described in "Engineering News" of Oct. 1, 1914, and Dec. 30, 1915.

**A Patent Decision of Great Importance** affecting the metallurgical industry was made by the Supreme Court of the United States on Dec. 11, sustaining patent No. 835,120 on the flotation process of mineral separation. According to the "Engineering and Mining Journal," which comments on the decision in its issues of Dec. 16 and 23, about 25,000,000 tons of ore were treated by this process in 1916, about half under license and the remainder in defiance of the patentee. The litigation over the patent has been in progress more than five years. In 1913 the District Court held the patent to be valid. This decision was reversed a year later by the Court of Appeals, and many mining companies concluded that the patent was void and therefore ceased to recognize it. Ordinarily, the Court of Appeals' decision is final. In this case appeal was taken to the Supreme Court of the United States because of the international character of the invention, the patent being owned by Englishmen and having been sustained by an appeal by the British House of Lords. An unprecedented feature in the case was that demonstrations of the patented process were made before the judges of the Supreme Court. The process covered by the patent is the so-called flotation process and its essential feature is the use of a very small amount of oil, less than 1% of the weight of the ore treated. Various other methods of ore separation by the use of oil have been previously invented and operated in which a much larger quantity of oil was used, and the essential feature of the patent now sustained is the use of an extremely minute quantity of oil, which is beaten up with the ore to form a very light froth.

## PERSONALS

**William H. Marshall** has resigned as President and Director of the American Locomotive Co., New York City.

**S. B. Taylor,** Sales Manager of the S K F Ball Bearing Co., Hartford, Conn., has been elected Vice-President of the company.

**L. D. Hollingsworth** has been appointed Division Engineer of the Department of Public Roads of Kentucky, with headquarters at Paducah, Ky.

**Henry B. Joy** has resigned as chairman of the Board of Directors of the Packard Motor Co., Detroit, Mich., owing to the pressure of other work.

**George F. Blackie,** Engineer of Roadway and Track of the Nashville, Chattanooga & St. Louis Ry., has been promoted to be Assistant Chief Engineer.

**C. P. Ross,** formerly of the engineering department of the Union Pacific R.R., has been appointed Industrial Agent, with headquarters at Omaha, Neb.

**Edwin G. Foster,** Assistant Engineer of the Buffalo, Rochester & Pittsburgh Ry., has been promoted to be Valuation Engineer, with office at Rochester, N. Y.

**L. D. Busby,** Chief Sanitary Inspector of the Bureau of Sanitation of Dallas, Tex., has resigned, and the office has been taken over by the Superintendent of the Street Department.

**Christopher H. Snyder,** M. Am. Soc. C. E., Designing and Consulting Engineer, San Francisco, Calif., has been appointed Lecturer in Civil Engineering at the University of California.

**G. A. Ungar,** formerly representative of the S K F Ball Bearing Co., of Hartford, Conn., in Cleveland, Detroit and Pittsburgh, has been appointed Technical Manager and Chief Engineer of the company.

**Frederick G. Keyes,** recently Chief Engineer of the Cooper Hewitt Electric Co., has been appointed to take charge of the research laboratory of physical chemistry at the Massachusetts Institute of Technology.

**H. H. Trabue,** Assistant Chief Engineer of the Nashville, Chattanooga & St. Louis Ry., with headquarters at Nashville, Tenn., has been appointed Real Estate Agent, reporting directly to the President of the company.

**T. B. Shertzer,** Assoc. M. Am. Soc. C. E., of the Texas Company, New York City, has been appointed City Manager of Portsmouth, Va. This position was advertised in "Engineering News" of Sept. 21, and there were 157 applicants.

**William S. Murray,** F. Am. Inst. E. E., has resigned as Consulting Engineer of the New York, New Haven & Hartford R.R., effective Dec. 31. From 1905 to 1914 he was in charge of the electrification of the New York division of the railway from New Haven to New York.

**Otto H. Kahn,** a New York City banker, has been elected a life member of the corporation of the Massachusetts Institute of Technology. The corporation of the institute now includes such well-known financial leaders as Theodore N. Vail, Frank A. Vanderlip and Coleman and Pierre du Pont.

**Joseph H. O'Brien,** M. Am. Soc. C. E., Managing Engineer, Westinghouse Church Kerr & Co., New York City, has been elected Vice-President of the reorganized Central Construction and Supply Co., Harrisburg, Penn., which will engage in general contracting under the name of the General Construction Corporation.

**Morse W. Rew** has accepted a position as assistant engineer with the Transit Commission of the City of Pittsburgh, of which E. K. Morse is the Commissioner. Since August, 1913, Mr. Rew has been an Assistant Engineer with the Cincinnati Rapid Transit Commission, and prior to this with the Boston Transit Commission.

**Thomas H. Means,** M. Am. Soc. C. E., of Symmes & Means, Consulting Engineer, San Francisco, Calif., has been appointed Consulting Engineer of the Anderson-Cottonwood Irrigation District, Redding, Calif., succeeding H. H. Henderson, M. Am. Soc. C. E., resigned. **E. R. Davis** has been appointed Superintending Engineer of the project.

**E. W. P. Smith,** Assoc. Am. Inst. E. E., for the past three years City Electrician of Cleveland, Ohio, has resigned to accept the position of Consulting Engineer of the Elliott Electric Co., Cleveland. He is a graduate of Colorado College, Colorado Springs, and has had experience with the Westinghouse Electric and Manufacturing Co. and in the mechanical department of the Lake Shore & Michigan Southern Ry.

**George B. Tripp,** Assoc. Am. Inst. E. E., Vice-President of the United Gas and Electric Corporation, a management company, of New York City, has reorganized and is to be President of the Central Construction and Supply Co., of Harrisburg, Penn. The new concern will be called the Central Construction Corporation and it will engage in a general contracting business. The capital is to be $600,000.

**Frank B. Jewett,** F. Am. Inst. E. E., former Assistant Chief Engineer of the Western Electric Co., New York City, has been made Chief Engineer to suceed C. E. Scribner, whose resignation was noted in these columns Dec. 21. He is a graduate of Throop Polytechnic Institute and of the University of Chicago, where he received a Ph.D. degree in 1902. For two years following he was an instructor at the Massachusetts Institute of Technology and then became connected with the American Telephone and Telegraph Co., where he had charge of transmission development work. In April, 1912 he was appointed Assistant Chief Engineer of the Western Electric Co.

**E. R. Gayler,** M. Am. Soc. C. E., Civil Engineer, United States Navy, has been appointed by the President an Engineer Advisor to direct the public-works improvements of Hayti, in

accordance with the treaty recently ratified between this country and the West Indian republic. Mr. Gayler was graduated from Washington University in 1895. He entered the Navy as an Assistant Civil Engineer in 1902. His duties since then have been particularly along the lines of developing new naval stations. He did much of the pioneer work at the Naval Stations at New Orleans, Charleston, S. C.; and Pearl Harbor, Hawaii. For the last two years he has been on duty at the Navy Department in Washington in connection with the dry dock at Pearl Harbor, H. I.

## OBITUARY

**Otto C. Wolf,** Architect and Engineer, of Philadelphia, Penn., died Dec. 19, aged 60 years.

**George R. Sawyer,** a civil engineer, of Pendleton, Ore., died Dec. 13. He was formerly County Engineer of Lincoln and Franklin Counties, Washington.

**Harry L. Hollman,** a civil and mining engineer, of Pittsburgh, Penn., died Dec. 18 at his home in that city, aged 51 years. He was graduated from the Western University of Pennsylvania (now the University of Pittsburgh) in civil engineering. After a short time with the Pittsburgh & Lake Erie R.R. he was chiefly engaged in coal-mine engineering.

**Roberdeau Buchanan,** Astronomer and until about five years ago Mathematician of the Nautical Almanac Office, U. S. Naval Observatory, Washington, D. C., died Dec. 18, aged 77 years. He was graduated from Lawrence Scientific School, Harvard University, in 1861. He became connected with the Nautical Almanac in 1879, and for many years made computations for it.

**George S. Haley,** President of the General Engineering and Management Corporation, of New York City, died Dec. 3 from injuries received by a motor truck on a New York street. He was born at Manchester, N. H., and was graduated from the University of Iowa. For a number of years he was Manager of the City Electric Co. and of the Rutland Railway, Light and Power Co., Rutland, Vt. From 1912 to June, 1916, he was Vice-President and General Manager of the Texas Power and Light Co., Dallas, Tex.

**Harry C. Francis,** a well-known Mechanical Engineer, of Philadelphia, Penn., died in that city Dec. 18. He was born in Philadelphia in 1842. He was graduated from the Central High School and his first engineering experience was with the Baldwin Locomotive Works. Later he was with William Sellers & Co. He is said to have had charge of engineering work in connection with the installation of the first electric street lighting in New York City. He was one of the organizers of the Kensington Engine Works, Ltd., of Philadelphia.

**Thomas E. Calvert,** Chief Engineer of the Chicago, Burlington & Quincy R.R., died at his home in Lincoln, Neb., on Dec. 19. He was born at Philadelphia in 1849. In 1870 he was graduated from Yale University, and in 1871 he began his railway career in the engineering department of the Chicago, Burlington & Quincy R.R. In 1875 he was made Division Engineer of the Nebraska division, and later became General Superintendent of the lines west of the Missouri River, retaining this position until 1905, when he was appointed Chief Engineer.

**Henry E. Fairchild,** Vice-President of the H. Wales Lines Co., Meriden, Conn., died Dec. 16. He was born in Woodbridge, Conn., in 1838, and as a youth learned the trade of a mason. In 1868 he became connected with the firm of Perkins & Lines, building contractors, of Meriden. Upon the retirement of Mr. Perkins, Mr. Fairchild became a member of the firm under the name of H. Wales Lines & Co. Later the H. Wales Lines Co. was incorporated. Mr. Fairchild was Superintendent of Construction of the company for a number of years. About eight years ago he retired from active work.

**Ferdinand M. Hausling,** head of the F. M. Hausling Co., building wrecking engineers and contractors, died Nov. 24. He was born in Newark, N. J., in 1860. He was educated at Heidelburg, in Germany, at Stevens Institute of Technology and at Columbia University. His first engineering experience was in mining work in Gunnison County, Colorado. After several years' experience in various branches of engineering and chemistry he became interested in building construction and demolition. He organized the F. M. Hausling Co. to scientifically tear down buildings and salvage the materials. This company removed many famous old buildings in New York City, including the former New York Life Building. He was of a scientific and analytical disposition and gave much time to a study of waterproofing methods. In 1904 he entered the field of waterproofing engineering with a process generally known as the Hausling method of waterproofing. Since then he largely devoted himself to this work, and at the time of his death was President and General Manager of the Anti-Hydro Waterproofing Co. of New York City.

## ENGINEERING SOCIETIES

SOCIETY OF AUTOMOBILE ENGINEERS.
Jan. 11. Annual meeting in New York City. Secy., C. F. Clarkson, 129 West 39th St., New York.

COMPRESSED GAS MANUFACTURERS' ASSOCIATION.
Jan. 15. Fourth annual meeting in New York City. Secy., O. S. King, 120 Broadway, New York.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
Jan. 17-18. Annual meeting at Society House, New York City. Secy., Charles Warren Hunt, New York.

WESTERN BRICK MANUFACTURERS' ASSOCIATION.
Jan. 20. Meeting in Kansas City, Mo. Secy., G. W. Thurston, 416 Dwight Building, Kansas City.

CANADIAN SOCIETY OF CIVIL ENGINEERS.
Jan. 23-25. Annual meeting in Montreal, Can. Secy., C. H. McLeod, 176 Mansfield St., Montreal.

ILLINOIS SOCIETY OF ENGINEERS.
Jan. 25-26. At Chicago. Secy., E. E. R. Tratman, Wheaton, Ill.

AMERICAN ROAD BUILDERS' ASSOCIATION.
Feb. 5-9. Eighth National Good Roads Show, in Boston, Mass. Secy., E. L. Powers, 150 Nassau St., New York City.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
Feb. 7-9. Midwinter convention in New York City. Secy., F. J. Hutchinson, 33 West 39th St., New York City.

TENTH CHICAGO CEMENT SHOW.
Feb. 7-15. In Chicago. Under management of Cement Products Exhibition Co., 210 South La Salle St., Chicago.

AMERICAN CONCRETE INSTITUTE.
Feb. 8-10. In Chicago at La Salle. Secy., H. D. Hynds, 30 Broad St., N. Y.

NATIONAL BUILDERS' SUPPLY ASSOCIATION.
Feb. 12-13. In Chicago at Sherman. Secy., L. P. Desmond, 1211 Chamber of Commerce, Chicago.

WISCONSIN ENGINEERING SOCIETY.
Feb. 15-16. At Madison, Wis. Secy., L. S. Smith, 939 University Ave., Madison, Wis.

SOUTHWESTERN CONCRETE ASSOCIATION.
Feb. 19-24. Southwestern Concrete Show in Kansas City, Mo. Address Chas. A. Stevenson, 1413 W. 10th St., Kansas City.

**The American Economic Association** will hold its 29th annual meeting meeting in Columbus, Ohio, Dec. 27 to 30, at the Hotel Deshler. The secretary is Allyn A. Young, Cornell University, Utica, N. Y.

**The Illinois Section** of the American Water-Works Association will hold its next meeting at the University of Illinois, Urbana, Mar. 13 and 14. The section secretary is Edward Bartow, Director State Water Survey, Urbana.

**The Mining and Metallurgical Society of America** has made the following nominations for officers for 1917: For president, W. R. Ingalls, Seeley W. Mudd and H. V. Winchell; for vice-president, Waldemar Lindgren; for secretary, Louis D. Huntoon.

**The Illinois Association of Members of the American Society of Civil Engineers** held its annual meeting in Chicago on Dec. 11. The officers for 1917 are as follows: President, C. F. Loweth; vice-presidents, A. N. Talbot and A. S. Baldwin; secretary, E. N. Layfield, Chicago.

**The American Association of Engineers** will hold a national convention Feb. 8 to 10 in Chicago, at the Hotel La Salle. It is stated that work of a promotional nature will constitute the greater part of the program, which will be held under the slogan, "For the Good of the Engineer."

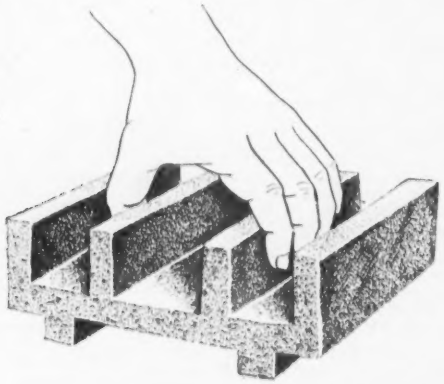
**The Idaho Society of Engineers** will hold its seventh annual convention in Boise, Jan. 18 to 20, in conjunction with the Operation and Maintenance Conference of the Uited States Reclamation Service, which is to be held Jan. 16 to 18. The secretary of the Idaho Society is Ira Shaffner, Boise.

**The Providence (R. I.) Engineering Society** was recently reorganized and its membership increased by nearly 300. Regular monthly meetings are now held either at Brown University or at Memorial Hall, while frequent meetings will be held in the club rooms, at which there will be informal discussions and talks on engineering topics of a more specialized nature. The society has been divided into five sections, all members of the society being invited to all section meetings. These sections are as follows: Fire Insurance and Fire Protection; Machine Shop; Designing and Drafting; Efficiency and Scientific Management; Structural Engineering. The president of the society is Prof. J. A. Brooks, Brown University; the vice-presidents are Robert W. Adams, George A. Carpenter, Wayland T. Robertson; the recording secretary is William A. Kennedy; corresponding secretary, Albert E. Thornley, Narragansett Machine Co., Pawtucket, R. I.; the treasurer is Alfred H. Whatley.

# Appliances and Materials

### Tapestry-Brick Building Tile

An interlocking channel brick with "tapestry" surface is being made by Fisk & Co., of New York and Boston, under the trade name "Fisklock." As seen from the accompanying sketch, every brick mechanically is both a header and a stretcher; a wall laid up of these tiles is in effect a double wall with a 2-in. air space between, the lower ribs and mortar filling the outer channels. For corners, window jambs, arches, belt courses, ornamental panels, etc., solid blocks of the same texture and shade are used, obviating the necessity of a variety of shapes and sizes. It is claimed that



INTERLOCKING CHANNEL BRICK

such a wall has double the strength of the solid and 125% the strength of one of hollow tile. The air cells being horizontal prevents internal air currents. Plaster may be applied directly to the inside of such walls without furring.

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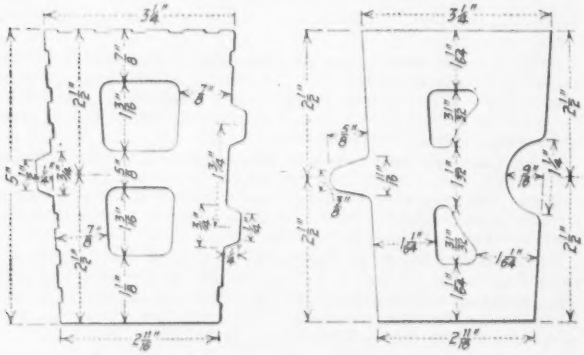
### California Radial Brick for Sewers

The accompanying sketches show the sectional outlines of new radial bricks being made by the Los Angeles Pressed Brick Co., of Los Angeles. The brick at the right is an improved type for storm drains, etc. The surface has roughing



FROST RADIAL INTERLOCKING BRICKS

grooves for bonding the mortar; the tongue and groove are replaced by side buttons. The number of brick per linear foot runs from 54 for a 36-in. conduit to 90 for a 60-in.

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### New Four-Cylinder Automobile Engine

The White Co., of Cleveland, maker of automobiles and motor trucks, announces that it has developed a new four-cylinder gasoline engine with increased power, speed, pick-up and silent operation. The prominent feature of the new engine is the use of 16 valves in place of the usual 8, making valve capacity better proportioned to cylinder displacement and rendering it unnecessary to resort to more than four cylinders for the larger powers.

### Quick-Acting Wrench

A new three-piece quick-acting nut wrench has been put out by the Cochran Pipe Wrench Co., 7800 Woodlawn Ave., Chicago, under the trade name "Speednut." As may be seen

COCHRAN "SPEEDNUT" WRENCH

in the accompanying sketch, one jaw is fixed and the other jaw slides in guides, being moved by a rack on it and a gear segment on the handle, which is pivoted.

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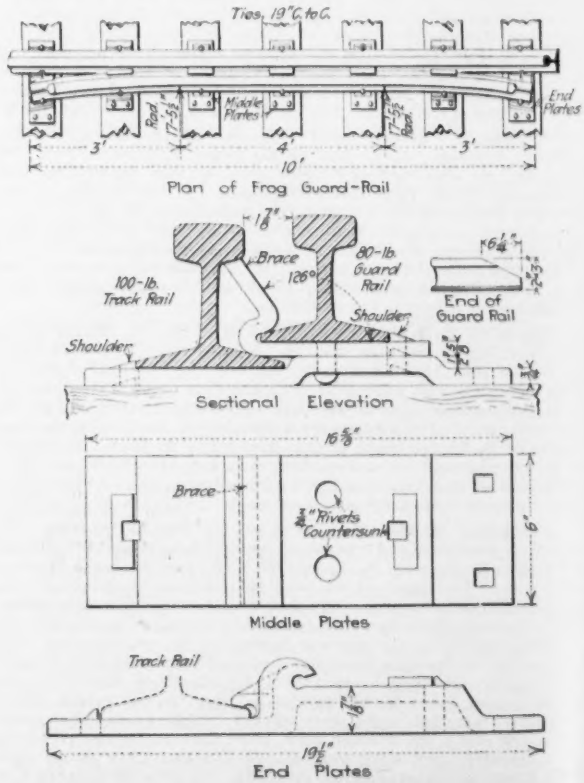
### Guard-Rail Holder for Frogs and Curves

The Betts guard-rail construction shown herewith has long tie-plates with supporting chairs so arranged that the guard rail may be of less height and weight than the track rail and yet have its top ⅜ in. higher than the head of the latter. Thus, an 80-lb. guard rail may be used on track laid with 100-lb. rails. This construction is adapted for the guard rails at frogs and those used on sharp curves.

For use at frogs, as shown in the drawing, the guard rail is 10 ft. long, straight for 4 ft., and supported on seven ties, with tie-plates extending under both rails. On the three ties at the middle, this rail has the inner edge of its base held by inclined braces that fit under the head of the track rail. On the two plates at each end, it is held by a hook or lug. On each plate there are lugs to engage the outer edges of the guard rail and the track rail. The end plates also have a fastening for the metal footguards. The ends of the guard rail are cut at an incline, so as not to catch hanging break-beams, etc.

This device is being used by a number of trunk-line railways and also by such terminal lines as the Chicago Junction Ry. and the Terminal Railroad Association of St. Louis. It is manufactured by the W. M. Mitchell Co., of Louisville, Ky.




THE BETTS GUARD-RAIL CONSTRUCTION